

RETROREFLECTIVE TRANSFER SHEET AND APPLIQUE

The present invention relates to retroreflective transfer sheets and graphic images produced therefrom, i.e., appliques.

5 During the growth in popularity of decorative appliques on garments such as T-shirts or jackets, there has been a continuing desire for ways to make such appliques retroreflective. Retroreflective appliques have the ability to return a substantial portion of incident light in the direction from which the light originated. On an outer garment worn at night, such retroreflective appliques provide a bright
10 return of light to oncoming motorists, thereby adding a safety feature, as well as increased decorative appeal, to the garments.

A retroreflective applique typically includes a layer of optical lens elements, a polymeric binder layer, and a specular reflective layer. The optical lens elements usually are transparent microspheres that are partially embedded in the polymeric
15 binder layer such that a substantial portion of each microsphere protrudes from the polymeric binder layer. The specular reflective layer is disposed on the portion of the transparent microsphere that is embedded in the polymeric binder layer and typically comprises aluminum, silver, or a dielectric mirror. Light striking the front surface of the retroreflective applique passes through the transparent microspheres,
20 is reflected by the specular reflective layer, and passes back through the transparent microspheres to travel back in the direction of the light source.

Several methods are known or have been proposed to provide such retroreflective appliques. One such method involves applying a layer of glass microspheres over a printed design; however, this layered product is stiff and
25 unsuitable for conformable garments. Another method involves silk-screening a design onto a garment, and then while the design is still wet, cascading microspheres onto the design; however, such an approach is messy, usually provides a nonuniform deposit of microspheres, and is impractical for obtaining high reflective brightness. Yet another method involves mixing hemispherically
30 specularly coated glass microspheres into ink and printing this onto the garment;

however, this results in a reduced retroreflectance because the hemispherically coated microspheres are randomly oriented within an applied coating.

5 In addition to being conformable or drapable so they can be used on garments, retroreflective appliques should be able to withstand laundering conditions. Examples of launderable retroreflective appliques are disclosed in U.S. Patent Nos. 4,763,985 (Bingham), 5,200,262 (Li), and 5,283,101 (Li). These appliques, however, are not imagewise printed appliques, nor are they prepared using compositions having a viscosity or volatility that are suitable for imagewise printing, especially by screen printing. Furthermore, retroreflective appliques
10 having multicolored designs are particularly desirable. Examples of multicolored retroreflective appliques are disclosed in U.S. Patent Nos. 4,102,562 (Harper et al.) and 5,344,705 (Olsen), and PCT Application No. WO 92/07990 (Olsen et al.). Retroreflective appliques that can be multicolored, conformable and drapable, and exhibit very little loss of retroreflective brightness after a significant number of washings, are extremely desirable.

15 U.S. Patent No. 5,344,705 (Olsen) and PCT Application No. WO 92/07990 (Olsen et al.) disclose a retroreflective transfer sheet material comprising a base sheet; a continuous layer of transparent microspheres partially embedded in a heat-softenable layer on the base sheet; a two-part resin composition comprising a polyester and an isocyanate hardener printed on the microsphere layer in an
20 imagewise pattern; a two-part resin composition comprising a polyurethane or a polyester, an isocyanate hardener, and reflective flakes printed directly on the microspheres or on the polyurethane-based resin; and a two-part extender resin comprising a polyurethane or a polyester and an isocyanate hardener printed in an
25 imagewise pattern. Before the extender resin is hardened, a powdered hot melt adhesive is applied to the wet image. This powdered hot melt adhesive must be fused into the extender resin through the application of heat. After the image dries, the powdered hot melt adhesive is removed from the nonimage areas. This transfer sheet material is used by laying it on a substrate, with the transfer layer against the
30 substrate, adhering the transfer layer to the substrate, and then stripping the base sheet and heat-softenable layer away.

The resulting transferred applique shows good home wash durability; however, the image is stiff and hard. This attribute leads to cracking when the fabric having the applique thereon is washed or flexed. These cracks serve as erosion and abrasion sites for further image and brightness degradation during wear and laundering. If appliques made with these systems are applied to a substrate fabric that stretches, the image will break or crack open, leaving islands of the now broken image that move with the stretched fabric. When the fabric is allowed to return to its rest position, the islands of image do not completely join to reform an uninterrupted image. The cracks between image pieces remain open and are sites where wash erosion and wear abrasion can start.

U.S. Patent No. 4,102,562 (Harper et al.) discloses appliques that are softer and more flexible than the appliques of Olsen; however, they do not wash well. The Harper et al. transfer sheet comprises a base sheet; a continuous layer of transparent microspheres partially embedded in a heat-softenable layer on the base sheet; a specular reflective layer (typically, a dielectric mirror) deposited onto the exposed surfaces of the microspheres; and a thick transfer layer (typically, a color layer) of a vinyl plastisol ink printed over the microsphere layer in an imagewise pattern. An adhesion-promoting layer comprising a silane is coated on the microspheres prior to the vinyl plastisol ink being coated thereon. This adhesion-promoting layer includes either a glycidoxypopyltrimethoxysilane or a polyurethane and a silane having reactivity toward polyurethane. Although Harper et al. disclose that they believe the silane provides a chemical linkage between the vinyl plastisol ink and the glass beads, the applique does not retain its retroreflective brightness because the microspheres tend to fall off after only a few washings. In fact, Harper et al. disclose that after only five machine washings, the appliques on sample garments displayed a 60% loss in retroreflectivity.

Thus, what is needed is a retroreflective applique that is softer, more durable, and easier to manufacture than conventional retroreflective appliques and transfer sheets for applying such appliques to a substrate, such as an article of clothing, for example.

The present invention provides a retroreflective applique comprising: a layer of optical lens elements partially embedded in and protruding from a transfer adhesive layer prepared from ingredients comprising a vinyl plastisol and a substantially nonhydrolyzed aminosilane adhesion promoter. Thus, the vinyl
5 plastisol and substantially nonhydrolyzed aminosilane adhesion promoter are the major reaction components, although other ingredients can be present. The aminosilane adhesion promoter is used in an amount effective to provide a retroreflective applique that is capable of retaining at least about 60% of its initial retroreflectivity after being laminated to 65/35 polyester/cotton blend fabric (100
10 g/m²) at about 174°C and about 2.8 Kg/cm² pressure for about 20 seconds and subjected to home laundering conditions five times, and at least about 40% of its initial retroreflectivity after being laminated to 65/35 polyester/cotton blend fabric (100 g/m²) at about 174°C and about 2.8 Kg/cm² pressure for about 20 seconds and subjected to home laundering conditions twenty-five times. To impart
15 retroreflectivity, the optical lens elements can be coated with a specular reflective material on the surface embedded in the transfer adhesive layer. Alternatively, reflective flakes can be distributed throughout the transfer adhesive layer.

The present invention also provides a retroreflective applique transfer sheet comprising the retroreflective applique discussed above and a carrier comprising a
20 layer of a heat-softenable material; wherein the layer of optical lens elements in the retroreflective applique is partially embedded in the heat-softenable material. Preferably, the transfer adhesive layer is disposed on the optical lens elements in an imagewise fashion.

The present invention also provides a kit for preparing a retroreflective
25 applique comprising:

- (a) a base sheet material comprising:
 - (i) a carrier comprising a heat-resistant backing and a layer of a heat-softenable material coated thereon; and
 - (ii) a layer of optical lens elements partially embedded in and
30 protruding from the heat-softenable material;

- (b) ingredients for preparation of a transfer adhesive composition comprising a vinyl plastisol and a substantially nonhydrolyzed aminosilane.

5 The aminosilane adhesion promoter is used to prepare the transfer adhesive composition in an amount effective to provide a retroreflective applique that is capable of retaining at least about 60% of its initial retroreflectivity after being laminated to 65/35 polyester/cotton blend fabric (100 g/m²) at about 174°C and about 2.8 Kg/cm² pressure for about 20 seconds and subjected to home laundering conditions five times, and at least about 40% of its initial retroreflectivity after being
10 laminated to 65/35 polyester/cotton blend fabric (100 g/m²) at about 174°C and about 2.8 Kg/cm² pressure for about 20 seconds and subjected to home laundering conditions twenty five times. The base sheet material of the kit can be a vapor coated sheet material comprising: a carrier comprising a heat-resistant backing and a layer of a heat-softenable material coated thereon; a layer of optical lens elements
15 partially embedded in and protruding from the heat softenable material; and a specular reflective material coated on the surfaces of the optical lens elements protruding from the heat-softenable material. Alternatively, the kit can include reflective flakes for mixing with the transfer adhesive composition.

Also provided is a method for preparing a retroreflective applique; the
20 method comprising:

- (a) providing a base sheet material comprising:
- (i) a carrier comprising a heat-resistant backing and a layer of a heat-softenable material coated thereon; and
 - (ii) a layer of optical lens elements partially embedded in and
25 protruding from the heat-softenable material; and
- (b) imagewise printing a transfer adhesive composition prepared from ingredients comprising a vinyl plastisol and a substantially nonhydrolyzed aminosilane adhesion promoter to form a retroreflective applique transfer sheet; wherein the aminosilane
30 adhesion promoter is used in an amount effective to provide a retroreflective applique that is capable of:

- 5 (i) retaining at least about 60% of its initial retroreflectivity after being laminated to 65/35 polyester/cotton blend fabric (100 g/m²) at about 174°C and about 2.8 Kg/cm² pressure for about 20 seconds and subjected to home laundering conditions five times; and
- 10 (ii) retaining at least about 40% of its initial retroreflectivity after being laminated to 65/35 polyester/cotton blend fabric (100 g/m²) at about 174°C and about 2.8 Kg/cm² pressure for about 20 seconds and subjected to home laundering conditions twenty five times.

FIG. 1 is an enlarged sectional view through a portion of a retroreflective transfer sheet of the present invention having a layer of a transfer adhesive comprising a plastisol and an aminosilane adhesion promoter mixed therein;

15 FIG. 2 is an enlarged sectional view through a portion of an alternative embodiment of the retroreflective transfer sheet shown in FIG. 1;

FIG. 3 illustrates schematically in a sectional view removal of the carrier from the transfer sheet shown in FIG. 1 after having been laminated to a substrate; and

20 FIG. 4 is a top plan view of an illustrative emblem transferred onto a substrate according to the present invention.

The present invention provides a retroreflective applique, transfer sheet bearing the retroreflective applique, an article, such as an article of clothing, bearing a transferred applique, and a method of preparing the retroreflective transfer sheet. The appliques of the present invention display substantial improvements over
25 conventional appliques with respect to durability, flexibility, stretch, and types of substrates to which they can be applied. Particularly preferred embodiments of the present invention are: (a) capable of reproducing complex images without costly and complex "weeding" operations (that is, without having to remove imaging material not part of the imaged region); (b) very durable to home laundering
30 conditions, as measured by retention of a large portion of its original retroreflective brightness after a large number of launderings; (c) very soft and flexible such that

the transferred applique approaches and preferably takes on the drape and flexibility of the fabric itself; and (d) able to be used on truly stretchable fabrics such that the transferred applique stretches with the fabric in normal, intended use and, when stretched beyond its maximum limit, the applique forms cracks and pinholes that generally close on return of the fabric to its rest position.

The retroreflective appliques of the present invention include a layer of optical lens elements, such as glass microspheres, which are preferably coated with a specular reflective material, and a transfer adhesive comprising a vinyl plastisol. A plastisol comprises finely divided resin particles, such as polyvinyl chloride particles, dispersed in a compatible plasticizer. It typically does not include organic solvents. As used in this context, "compatible" means that the resin particles can coexist on the molecular scale with the plasticizer such that the resin particles and plasticizer form a stable association with each other. Typically, this means that the resin particles are capable of being substantially solubilized in the plasticizer at an elevated temperature. Preferably, the solubility parameter d , which is an experimentally determined property (i.e., $[(L-RT)/(M/D)]^{1/2}$ wherein L is the latent heat of vaporization, R is the gas constant, T is the absolute temperature, M is molecular weight, and D is density), for the resin particles is within about two units ($\text{MPa}^{1/2}$) of the solubility parameter of the plasticizer. Further discussion of the solubility parameter can be found in J.A. Brydson, *Plastics Materials*, 5th edition, Butterworths, London, pages 75-84 and 125-126 (1989).

In the plastisols of the present invention, the resin particles typically have a particle size of about 0.5-150 micrometers. If the particle size of the resin particles is about 0.5-2 micrometers, it is typically considered a "dispersion" resin. If the particle size of the resin particles is about 10-150 micrometers, it is typically considered an "extender" resin. A typical composition includes about 60-100 parts dispersion resin, about 0-40 parts extender resin, and about 30-100 parts plasticizer. Typically, the plastisol is in the form of a paste that gels when heated as a result of solvation of the resin particles by the plasticizer.

Typically, because plastisols are in the form of a paste, they are particularly desirable for application of thick layers, although it is desirable that they be of a

consistency suitable for printing. Furthermore, they can be printed in organic solvent-free form and then gelled upon the application of heat for a short period of time. This gelled state results from partial dissolution of the particles in the plasticizer and partial coalescence of the particles to form a very weak image that is generally dry to the touch and can withstand mild rubbing without smearing. Once in the gelled state, the further application of heat during lamination causes the gelled plastisol to temporarily soften and flow and/or penetrate a substrate, such as a fabric. During this process the particles are further dissolved by the plasticizer, and upon cooling, they are fused into a hard rugged image.

A wide variety of vinyl plastisols can be used as the transfer adhesive in the retroreflective appliques and transfer sheets of the present invention. Homopolymer resin plastisols as well as copolymer resin plastisols can be used. Homopolymer resins comprise particles polymerized from a single monomer unit, such as vinyl chloride, whereas copolymer resins comprise particles polymerized from mixtures of monomers. A preferred class of resins are resins made from vinyl chloride monomers. Copolymers made from vinyl chloride and a monomer selected from the group consisting of vinyl acetate, maleic anhydride, maleic acid, a maleic acid ester, vinyl ether, acrylic acid, an acrylic acid ester, and mixtures thereof may also be used. Copolymers that include carboxylated monomer units tend to adhere more tightly to glass and metal surfaces; however, they are also difficult to work with because they are very viscous. Thus, they do not print in an imagewise fashion easily and are therefore less desirable vinyl plastisols for use in the present invention. Furthermore, the improvement in wash durability obtained using copolymers that include carboxylated monomer units compared with appliques made with homopolymer plastisols, is much less than the improvement achieved by the present invention. Thus, a preferred class of vinyl resins are made from monomers selected from the group consisting of vinyl chloride, vinyl acetate, vinyl ether, and mixtures thereof. A particularly preferred class of vinyl resins are made from vinyl chloride and a monomer selected from the group consisting of vinyl acetate, vinyl ether, and mixtures thereof.

A wide variety of plasticizers suitable for use in the vinyl plastisols that can be used as transfer adhesives in the present invention include nonvolatile organic liquids. Typical classes of plasticizers that are compatible with vinyl particles include, but are not limited to, terephthalate esters, isophthalate esters, and orthophthalate esters, nonlimiting examples of which include butyl benzyl phthalate, dihexyl phthalate, di-2-ethylhexyl phthalate, diisooctyl phthalate, diisononyl phthalate, and dodecyl phthalate; adipates, nonlimiting examples of which include dioctyladipate, diisononyladipate, di-2-ethylhexyl adipate, and adipates of straight chain C6-C10 alcohols; azelates, nonlimiting examples of which include dioctylazelate and diisooctyl azelate; sebacates, nonlimiting examples of which include dioctyl sebacate; trimellitates, nonlimiting examples of which include trioctyl trimellitate and triisononyl trimellitate; polymeric plasticizers with a molecular weight of about 1,000-10,000 resulting from the esterification of dibasic acids with glycols; phosphates, nonlimiting examples of which include tricresylphosphate, cresyldiphenylphosphate, and octyldiphenylphosphate; and epoxides, a nonlimiting example of which is epoxidized soybean oil. These materials may be used alone or in combination and are typically commercially available. For example, diisononyl phthalate is commercially available under the trade designation "JAYFLEX DINP" from Exxon Chemical Co., Houston, TX; di-2-ethylhexyl adipate is commercially available under the trade designation "PX-238" from Aristech Chemical Co., Pittsburgh, PA; trioctyl trimellitate is commercially available under the trade designation "PX-338" from Aristech Chemical; tricresylphosphate is commercially available under the trade designation "KRONITEX TCP" from FMC Corporation, Philadelphia, PA; and epoxidized soybean oil is commercially available under the trade designation "PX-800" from Aristech Chemical.

Suitable vinyl plastisols can be prepared by combining at least one type of vinyl resin with at least one type of compatible plasticizer, as discussed above. Although the inventor does not wish to be held to any particular theory, the plasticizer tends to soften the vinyl resin and lower its processing temperature. Thus, vinyl plastisols can typically be fused at temperatures as low as about 150°C,

which is desirable for application of the appliques of the present invention. Suitable plastisols are also commercially available.

A plastisol can also include additives such as heat stabilizers, fillers, colorants, volatile diluents, and the like. Heat stabilizers, such as Ba-Cd-Zn stabilizers available under the trade designations "S-1861" and "1528" from Synthetic Products Company, Cleveland, OH, and the like, aid in the prevention of polymer degradation caused by processing heat. If a heat stabilizer is used, it will typically be used in an amount of about 0.5-5 parts by weight, based on 100 parts vinyl resin. Surface active agents, such as those available under the trade designations "BYK 3105" and "BYK 4010" from Byk-Chemie, USA, Wallingford, CT, and the like, can be included in the plastisol formula to adjust viscosity and to assist in keeping a desired viscosity stable over time. If a surface active agent is used, it will typically be used in an amount of about 0.1-3 parts by weight, based on 100 parts vinyl resin. Colorants, i.e., dyes or pigments, such as those available under the trade designations "81Y312," "81S284," and "81R278" from Penn Color Co., Doylestown, PA, and the like, can be included to impart opacity, color, or weatherability properties. If a colorant is used, it will typically be used in an amount of about 0.5-5 parts by weight, based on 100 parts of vinyl resin. Fillers, such as chalks, clays, silica, and the like, may also be present in a plastisol formula to reduce cost, increase viscosity, or adjust electrical, tack, or scuff properties. If a filler is used, it will typically be used in an amount of up to about 50 parts by weight, based on 100 parts vinyl resin. Powdered or liquid adhesive enhancers can also be included to improve the adhesion of the image layer to its substrate. These can be of the hot melt powdered type such as polyamide or polyester hot melt adhesives, or they can be of the liquid resin type such as isocyanate resins, epoxy resins, or melamines. If a powdered or liquid adhesive enhancer is used, it will typically be used in an amount of about 0.5-5 parts by weight, based on 100 parts vinyl resin. Each of these types of additives provides some advantage for the specific application for which the plastisol is intended.

Examples of commercially available vinyl plastisols include those sold under the trade designations "PLUS 9090" from Union Ink Company, Inc., Ridgefield,

N.J., "TRANSFLEX 10210TF" from Flexible Products Company, Kennesaw, GA, and "SX 864A," "SX 864B," "SX 864C," "SX 864D," "SX 874A," "SX 874B," and "SX 863," all of which are available from Plast-O-Meric SP, Inc., Sussex, WI. All of these comprise vinyl particles uniformly dispersed in a plasticizer, such as an orthophthalate ester. Although these vinyl plastisols are colorless, similar ones are available that include colorants.

Typically, plastisols, particularly vinyl plastisols, do not adhere well to glass, metals, metal oxides or hydroxides, or dielectric metal complexes. Thus, the use of vinyl plastisols directly on coated glass microspheres, for example, in retroreflective appliques typically leads to poor wash durability. The present invention provides a method by which the adhesion of vinyl plastisols to coated glass microspheres is improved. This involves the incorporation of an aminosilane adhesion promoter in the plastisol and directly binding the plastisol to the optical lens elements, to their reflective coating, or to both. That is, there is no intervening binder layer, although there may be an intervening specular reflective material.

The retroreflective appliques and articles of clothing bearing them have been found to exhibit surprising retention of retroreflective brightness after being repeatedly laundered. This advantageous result is achieved through increased resistance to loss of retroreflective elements due to binding the vinyl plastisol to the optical lens elements. Consequently, articles bearing the retroreflective appliques of the present invention can be cleaned more times than previously thought possible while still retaining the desired retroreflective character.

When laminated to 65/35 polyester/cotton blend fabric (100 g/m²) at about 174°C and about 2.8 Kg/cm² pressure for about 20 seconds, retroreflective appliques of the present invention retain at least about 60%, preferably at least about 70%, more preferably at least about 80%, and most preferably at least about 90%, of their initial retroreflectivity after being subjected to home laundering conditions five times. Similarly, when laminated to 65/35 polyester/cotton blend fabric (100 g/m²) at about 174°C and about 2.8 Kg/cm² pressure for about 20 seconds, retroreflective appliques of the present invention retain at least about 40%, and preferably at least about 50%, of their initial retroreflectivity after being

subjected to home laundering conditions twenty five times. As used herein, "initial retroreflectivity" refers to the retroreflective brightness of the laminated applique prior to laundering. As used herein, "home laundering conditions" refer to the procedure described in the Examples Section. Briefly, this includes washing each sample for five consecutive cycles in a Maytag Model LS7804 automatic washing machine ("Regular" fabric (setting 10); "Large" load; and "Hot/Cold" temperature using an initial water temperature of about 43°C) with 40 grams of a standard detergent per wash cycle. After every fifth wash/rinse cycle, each sample is tumble-dried in a Maytag Model LS7804 dryer until the total load is dried (60°C temperature and "Regular" fabric), and then tumbled for a 5-10 minute cooling period with the heat turned off.

The appliques of the present invention are also able to withstand dry cleaning operations. Vinyl plastisols are customarily not expected to withstand dry cleaning operations. The vinyl plastisol transfer adhesive compositions of the present invention are able to withstand at least about twenty five dry cleaning operations without appreciable loss of brightness. It is believed that this is due to the presence of the aminosilane adhesion promoter. This is an additional and unexpected benefit of the present invention.

The appliques of the present invention also demonstrate substantial flexibility and stretchiness. For example, when subjected to the stiffness test described below in the Examples Section, appliques of the present invention demonstrate significantly smaller bending moments (about ten times less) than do appliques made according to U.S. Patent No. 5,344,705 (Olsen). Preferably, the appliques of the present invention have a maximum bending moment, as determined by Method 5205, Federal Test Method Standard No. 191A, of less than about 1×10^{-3} N·m, and preferably less than about 8×10^{-4} N·m.

The appliques of the present invention are also more readily laminated to a substrate without damaging the applique upon removal of the carrier. That is, the carrier can be removed with a relatively small peel force while leaving the edges of the applique sharp.

One embodiment of a retroreflective transfer sheet 10 according to the present invention is shown in Figure 1. An alternative embodiment of a retroreflective transfer sheet 10' is shown in Figure 2. These transfer sheets 10 and 10' each include a layer of optical lens elements in the form of microspheres 11 disposed on a carrier 12, which includes a heat-resistant backing 13 and a heat-softenable layer 14. The microspheres 11 are partially and releasably embedded in the heat-softenable layer 14. Herein, the backing 13 with the heat-softenable layer 14 and microspheres 11 is referred to as a "base sheet material." On the side of the base sheet material with the microspheres 11 is a layer of a transfer adhesive 15 comprising a plastisol.

This transfer sheet is used by laying it on a substrate, with the transfer adhesive layer against the substrate, adhering the transfer adhesive layer to the substrate through the application of heat, and then stripping the backing and heat-softenable layer away. This leaves the retroreflective applique adhered to the substrate. It includes a layer of optical lens elements partially embedded in and protruding from the transfer adhesive layer.

The backing 13 is preferably made of a material that does not melt or substantially degrade upon exposure to temperatures below about 210°C. Examples of suitable heat-resistant materials include polyethylene terephthalate and Kraft paper. Typically, polyethylene terephthalate is used when the optical lens elements are coated with a layer of aluminum and Kraft paper is used when the optical lens elements are coated with a layer of a dielectric material, although either backing material may be used with both types of coating on the optical lens elements. The heat-softenable layer 14 is firm and nontacky such that the optical elements can be easily removed from it during application of the applique. Preferably, it is made of a material that softens at a temperature of at least about 95°C. Examples of suitable heat-softenable materials include waxes, silicones, polyesters, polysulfones, polyvinyl chloride, and polyolefins such as low density polyethylene, polypropylene, polybutylene, and the like.

The optical lens elements are made of a material that is preferably substantially transparent so as to maximize the amount of incident light

retroreflected. As used herein, "transparent" means capable of transmitting light. Preferably, the optical lens elements are made of a material that is capable of transmitting at least about 80% of the intensity of incident light in the visible spectrum (about 400-700 nanometer wavelength). More preferably, the optical lens elements are made of a material that is capable of transmitting about 90% of the intensity of light in the visible spectrum. The optical lens elements are typically made of glass, although nonvitreous ceramic compositions or synthetic resins can also be used. Glass and ceramic optical elements are preferred because they tend to be harder and more durable. Typically, the optical lens elements are substantially colorless, but they can be tinted or colored if desired.

The optical lens elements can be microspheres that are preferably substantially spherical in shape for substantially uniform and efficient retroreflection. Typically, microspheres suitable for use in the present invention have a diameter of about 30-200 micrometers, preferably about 60-100 micrometers, and more preferably about 40-90 micrometers. Microspheres smaller than about 30 micrometers in diameter tend to provide lower levels of retroreflection, and microspheres larger than about 200 micrometers tend to impart undesirable texture and/or flexibility. Preferably, the microspheres are substantially uniform in size, i.e., within about 25% in diameter. Preferably, these microspheres have an index of refraction of about 1.7-2.0. Examples of microspheres that can be used in the present invention are disclosed in, for example, U.S. Patent Nos. 4,931,414 (Wood et al.); 4,772,511 (Wood et al.); 4,758,469 (Lange); 4,564,556 (Lang et al.); 4,367,919 (Tung et al.); and 4,192,576 (Tung et al.).

Referring to Figures 1 and 2, the microspheres 11 are packed in close proximity. Preferably, they are packed as closely as possible in their closest hexagonal arrangement, to achieve high retroreflective brightness. They are typically thermally embedded in the heat-softenable layer 14 to a depth of about 25-50%, preferably about 40-50%, of their diameter. This can be done by a variety of methods, such as by passing the carrier 12 and layer of microspheres 11 through a tunnel oven, for example, set at a temperature of about 95-135°C.

The retroreflective properties of the applique of the present invention is provided in one of two general ways. Referring to Figure 1, one such method includes the use of a layer of specular reflective material 16 such as a specular reflective metal or a dielectric mirror coated on the microspheres 11. Herein, the backing 13 with the heat-softenable layer 14 and microspheres 11 with the layer of specular reflective material 16 is referred to as a "vapor coated sheet material." In this embodiment, the specular reflective material is coated only on the surface of the microspheres that protrudes from the heat-softenable layer. Thus, when the applique is applied to a substrate, the rear surface of the microspheres (the surface embedded in the transfer adhesive layer) is coated with the specular reflective material.

Referring to Figure 2, another method includes the use of reflective flakes 17 distributed throughout the transfer adhesive layer 15. Thus, in this embodiment, the microspheres are not coated with a specular reflective material and the base sheet material on which the transfer adhesive is coated (or imagewise printed) does not include any specular reflective material. Rather, the reflective material is mixed with the transfer adhesive prior to its application to the base sheet material. It should be understood, however, that reflective flakes can be used in combination with optical lens elements coated with dielectric layers.

Referring to Figure 1, a variety of metals can be used to provide a specular reflective layer 16. These include aluminum, silver, chromium, gold, nickel, magnesium, and the like, in elemental form, and combinations thereof. In some instances, such as for aluminum, at least a portion of the metal can be in the form of a metal oxide and/or hydroxide. Aluminum and silver are the preferred metals for use in a reflective layer because they tend to provide the highest retroreflective brightness. Aluminum is more preferred because it generally provides better laundering durability when adhered to a glass optical element. The metal coating can be produced by vacuum or chemical deposition or electroless plating. The metal layer should be thick enough to reflect incoming light. Typically, the reflective metal layer is about 50-150 nanometers thick.

In lieu of, or in addition to, a reflective metal layer, a dielectric mirror can be used as a specular reflective material. The dielectric mirror can be similar to known dielectric mirrors disclosed, for example, in U.S. Patent Nos. 3, 700,305 (Bingham) and 4,763,985 (Bingham). Such mirrors include a number of layers of at least two different dielectric materials. When using a dielectric mirror, the optical lens elements typically have a refractive index n_2 and have one or more layers of transparent material disposed thereon that has a refractive index n_1 , and the opposite face of the layer(s) of transparent material is in contact with a one or more layers of material having a refractive index n_3 , where both n_2 and n_3 have a refractive index of at least 0.1, preferably at least 0.3, higher or lower than n_1 . The layers of transparent material typically have an optical thickness corresponding to odd numbered multiples (1, 3, 5, 7 . . .) of about one-quarter wavelength of light in the wavelength range of about 380-1,000 nanometers. Thus, either $n_2 > n_1 < n_3$ or $n_2 < n_1 > n_3$, and the materials on either side of the transparent layer(s) can be either both higher or both lower in refractive index than n_1 . When n_1 is higher than both n_2 and n_3 , n_1 is preferably about 1.7-4.9, and n_2 and n_3 are preferably about 1.2-1.7. Conversely, when n_1 is lower than both n_2 and n_3 , n_1 is preferably about 1.2-1.7, and n_2 and n_3 are preferably about 1.7-4.9. The dielectric mirror preferably comprises a contiguous array of materials, at least one being in layer form, having an alternating sequence of refractive indices. In a preferred embodiment the contiguous array has 2-7 layers, preferably 3-5 layers, adjacent to the lens element. A dielectric mirror can provide very good retroreflectivity, although it typically is not as efficient a reflector as is a reflective metal layer, unless a very large number of layers are used. Furthermore, a dielectric mirror tends to wash away more readily than does a reflective metal layer; however, the wash durability of appliques made using a dielectric vapor coated sheet material is substantially improved over that without the aminosilane adhesion promoter.

Among the many compounds that can be used in providing and an aminosilane adhesion promoter in the transfer adhesive composition transparent materials within the desired refractive index are: high index materials such as CdS, CeO₂, CsI, GaAs, Ge, InAs, InP, InSb, ZrO₂, Bi₂O₃, ZnSe, ZnS, WO₃, PbS,

PbSe, PbTe, RbI, Si, Ta₂O₅, Te, TiO₂; low index materials such as Al₂O₃, AlF₃, CaF₂, CeF₃, LiF, MgF₂, Na₃AlF₆, ThOF₂, elastomeric copolymers of perfluoropropylene and vinylidene fluoride, and the like. Other materials are reported in Thin Film Phenomena, K.L. Chopra, page 750, McGraw-Hill Book Company, New York, NY (1969). A preferred dielectric mirror contains
5 succeeding layers of cryolite (Na₃AlF₆) and zinc sulfide.

Another method for making the appliques of the present invention retroreflective includes the use of reflective flakes distributed throughout the transfer adhesive layer. Referring to Figure 2, reflective flakes 17 are shown in a
10 transfer adhesive layer 15 (not shown to scale). The reflective flakes are preferably metal flakes such as aluminum, bronze, or gold flakes, or nacreous pigment particles such as pearlescent pigments as disclosed in U.S. Patent No. 3,758,192 (Bingham). The reflective flakes are microscopic in size. Because the reflective flakes are so
15 much smaller than the microspheres, they can generally conform to the surfaces of the microspheres. Preferably, the reflective flakes are ellipsoidal in shape rather than rectangular. A suitable aluminum flake paste is available under the trade designation "MIRAL" 80,000/A/cx/70-30 from A. Van Lerberghe, Elleboogstraat 7, 8500 Kortrijk, Belgium. Several other aluminum pastes and powders are quite
20 suitable, including, for example, those available under the trade designations "SUPER FINE P" and "ETERNABRITE 601-1" from Silberline Manufacturing Co., Inc., Tamaqua, PA, and "CHROMAL X," "PCR 212," "PCA 501," from Obron Atlantic, Painesville, Ohio.

Referring to Figure 1, the surfaces of the microspheres protruding from the heat-softenable layer 14 have a transfer adhesive layer 15 disposed thereon to form
25 a retroreflective applique. As discussed above, this transfer adhesive layer comprises a vinyl plastisol. The transfer adhesive layer 15 is of a sufficient thickness to bond to the microspheres and to a substrate, without unnecessarily stiffening the applique. Thus, the thickness can vary depending on the diameter of the microspheres and the type of substrate. For example, when the sheet 10 is
30 intended to be used in transferring a design to a fabric substrate, there should be enough material in the transfer adhesive layer 15 to penetrate the fabric and thereby

attach the transferred adhesive to the fabric. Typically, the transfer adhesive layer 15 has a thickness of about 1-250 micrometers, preferably about 50-150 micrometers.

5 If the retroreflective applique is in the form of a specific image, the transfer adhesive layer is typically formed by "printing" (such as screen printing) an adhesive composition in an imagewise pattern. Thus, only a portion of the layer of optical lens elements would be covered by the transfer adhesive layer. The term "printing" or "printed" is used herein to include a variety of specific imaging processes, applied by hand, machine, or common mechanical or electronic methods, including
10 spraying, printing, lithographing, screen printing, hand painting, or other suitable application processes. The adhesive composition can be printed directly onto the layer of optical elements, or alternatively directly onto the reflective layer coated on the optical elements. In these embodiments there is no primer layer used.

Referring to Figures 1 and 2, if a layer of a transfer adhesive composition
15 containing only a vinyl plastisol is directly applied to the optical elements, or to the reflective layer coated on the optical elements, and the applique is laminated to fabric, the retroreflective brightness of the applique is greatly reduced upon washing the fabric, typically by the tenth wash. Typically, after the tenth wash according to the procedure described in the Examples Section, less than about 25% of the initial
20 brightness is retained. This is because vinyl plastisols do not adhere well to glass, metals, metal oxides or hydroxides, or metal complexes used in dielectric materials. An exception to this are the carboxylated vinyl plastisols; however, they are generally too viscous to use in imagewise printing operations.

The aminosilane adhesion promoter includes amine functional groups that
25 interact with the vinyl resin in the plastisol and with the optical lens elements or their reflective coating, or both. Although other functional groups can be present, the organosilane includes at least one amine group per molecule. Thus, amine-functional silanes (also referred to herein as "aminosilanes"), such as primary aminoalkyl silanes, secondary aminoalkyl silanes, and bis-silylalkyl amines, are particularly suitable for use with vinyl plastisols. In contrast, silanes such as g-
30 glycidoxypropyltrimethoxysilane, g-mercaptopropyltrimethoxysilane, and g-

isocyanatopropyltrimethoxysilane, which are commercially available under the trade designations "A-187," "A-189," and "A-1310," respectively, from OSi Specialties, Inc., Lisle, IL, generally provide no improvement in home wash durability when compared to samples containing no aminosilane adhesion promoter at the time of mixing with the plastisol. For effective adhesion, the aminosilanes are substantially nonhydrolyzed. By this it is meant, that typically less than about 5% by weight (wt-%) of the material is hydrolyzed. An example of a substantially hydrolyzed aminosilane is available under the trade designation "A-1106" from Osi Specialities, Inc. Use of substantially nonhydrolyzed aminosilanes promotes intermolecular interactions, such as with the optical lens elements, their specular reflective coatings, and with the vinyl plastisol, whereas aminosilanes hydrolyzed prior to mixing with the plastisol typically favor self interaction. Commercially available nonhydrolyzed aminosilanes include those available under the trade designations "A-1100" (γ -aminopropyltriethoxysilane), "A-1120" (N- β -(aminoethyl)- γ -aminopropyltrimethoxysilane), "A-1130" (the triaminofunctional silane $\text{H}_2\text{NCH}_2\text{CH}_2\text{NHCH}_2\text{CH}_2\text{NHCH}_2\text{CH}_2\text{CH}_2\text{Si}(\text{OCH}_3)_3$), and "A-1170" (bis-trimethoxysilylpropyl amine), all of which are available from OSi Specialties, Inc., Lisle, IL. Other amine-functional alkoxysilanes, such as the analogous methoxy or ethoxy silanes, are commercially available and suitable for use in the present invention.

The amount of aminosilane adhesion promoter used varies depending on the combination of aminosilane and vinyl plastisol and the desired level of wash durability, as measured by the retention of the initial, unwashed retroreflective brightness of an applique applied to a substrate. Typically, the amount of aminosilane adhesion promoter used is preferably at least about 1 wt-%, based on the total weight of the transfer adhesive composition, although higher amounts are required for certain aminosilanes. For example, for certain combinations of aminosilanes and vinyl plastisols, desirable durability is not obtained until about 9 wt-% of the aminosilane is present in the transfer adhesive composition. For other aminosilanes, desirable durability is obtained with as little as 1-2 wt-%, and no further improvement is seen above about 7 wt-%. For other aminosilanes, low

concentrations as well as high concentrations of aminosilane produce undesirable levels of wash durability. Furthermore, for carboxylated vinyl plastisols, for example, an amount of an aminosilane is required that is in excess of that which will react with all the carboxyl groups. Typically, however, for most combinations of aminosilanes and vinyl plastisols, desirable durability can be obtained with less than about 10 wt-% aminosilane. The desired amount of aminosilane can be readily determined by one of skill in the art with a minimal amount of routine experimentation.

The vinyl plastisol transfer adhesive composition is usually printed in a reverse image on a layer of optical lens elements, which protrude from a layer of heat-softenable material on a carrier, so that a positive image is formed when the applique is transferred to a substrate. A single printing step is used to apply the plastisol transfer adhesive composition. After the plastisol transfer adhesive composition is printed on the optical lens elements, it is dried, typically in an oven, preferably in a tunnel oven, so that the temperature of the entire thickness of the film making up the image reaches at least about 80-120°C. The resulting dried material is in a "gel" state and has sufficient internal cohesion so it can be handled without damage. It is, however, only partially progressed toward its final fused state, which occurs during the application of the applique to the substrate. During lamination of the applique to the substrate, temperatures of about 150-190°C are used for about 5-30 seconds.

The appliques applied to articles of clothing, for example, using the transfer sheets of the present invention are improved over conventional retroreflective appliques because they are easier to manufacture, they are more flexible and stretchable, and they demonstrate improved wash durability. For example, the use of a plastisol transfer adhesive eliminates the use of cumbersome and messy powdered transfer adhesives, which are hard to control, difficult to clean up, and may be physical irritants to the operators. Elimination of the powdered transfer adhesive also eliminates the processing step of brushing the extraneous powder from nonimaged areas the day after printing, and also eliminates the processing step of melting the powdered transfer adhesive left in the imaged areas of the newly

brushed transfers. Use of the plastisol transfer adhesive also eliminates the storage equipment and space, as well as labor required to store the imaged appliques made by conventional processes overnight before being able to proceed. When properly made and applied to fabric, transfer images made with conventional processes require at least 24 hours from the time of printing to the production of completed appliques applied to the substrate. By contrast, when properly made and applied, appliques of the present invention require approximately three minutes from the time of printing to the production of a completed applique applied to its substrate. Elimination of processing steps such as these that are required by conventional technology represents considerable savings of time, expense, labor, and equipment.

Furthermore, the use of a vinyl plastisol transfer adhesive provides a more flexible applique and a more wash durable applique. The elimination of solvent-borne materials, such as solvent-borne inks, eliminates the need for a two-step printing process, eliminates the problems associated with applying images in exact register, eliminates the problems associated with the safety, handling, and proper disposal of materials containing volatile organic compounds, and provides further improvement in the flexibility and wash durability of the applique. These appliques are extremely flexible and stretchable such that they can be used on LYCRA and other stretchable fabrics. Even if the applique is stretched beyond its maximum it will crack or break; however, if it is allowed to return to its rest position the cracks close and a whole image is formed again.

As stated above, in addition to the aminosilane adhesion promoter, metal flakes can be included within the transfer adhesive layer. Furthermore, colorants, such as pigments and dyes, can be included within the transfer adhesive layer. It will be understood by one of skill in the art that a wide variety of multicolored appliques can be prepared using only a single layer of the plastisol transfer adhesive described herein. For example, the multilayered appliques described in U.S. Patent No. 5,344,705 (Olsen) can be prepared using a single layer of the plastisol transfer adhesive described herein. The adhesive layer can be formed by successively printing (typically screen printing in an imagewise pattern) and drying a plurality of colorant adhesive compositions onto the microspheres. In other words, the transfer

adhesive layer can include a number of different colors, one for each colored segment of a multicolored design. Alternatively, segments can include a number of different colors mixed together to form a "hybrid" color in a single layer. Each colored area of the image is formed by a separately printed and gelled adhesive composition. In either case, the number of different colors or the "hybrid" color comprise different areas of the image that do not need to overlap and therefore are all on the same layer. All of these areas being thermoplastic, no imagewise second layer of transfer adhesive need be applied over the entire image as described in U.S. Patent No. 5,344,705 (Olsen). This eliminates the need to print two overlapping layers of different colors to achieve "hybrid" colors. For example, if a sheet material of the invention includes an image printed with a transfer adhesive composition of the invention made by mixing together transfer adhesive compositions of yellow and cyan, the resulting single layer of the image will be green.

Other additives such as fillers, thermal stabilizers, light stabilizers, antioxidants, flame retardants, flow modifiers, plasticizers, and elastomers can be included in the adhesive transfer layer and/or the binder layer. The selection of any of these additives is determined by a number of processing and durability factors; however, laundering durability is a particularly important factor.

The appliques of the present invention can be transferred to a fabric or other substrate by heat and pressure. The appliques can be applied to a variety of fabrics such as cotton, polyester, cotton/polyester blends, fabrics containing "LYCRA" fibers, as well as fire retardant fabrics such as "PBI/KEVLAR" and "NOMEX" fabrics. The appliques of the present invention can also be applied to vinyl surfaces and other plastic-like materials, such as the side of a truck, mud flaps, and protective clothing, for example. They can be applied to an article of clothing directly or transferred to a fabric substrate, for example, and the fabric sewn onto the article of clothing if desired.

In a typical application, a transfer sheet is placed so that the image is facing and in contact with the chosen substrate, and then placed in a thermal lamination device. Typical lamination conditions include a temperature of about 150-190°C, a

pressure of about 0.7-4.2 Kg/cm², and a time of about 5-30 seconds. After this, the construction is allowed to cool to room temperature and the carrier material is removed from the applique as shown in Figure 3.

5 Although the retroreflective sheet of the present invention preferably includes imagewise printed appliques, it can also be in the form of roll goods that do not have specific images thereon. The same components that are used in an imagewise manner to form retroreflective images can be coated, by knife coater or other coating means, on a carrier to produce retroreflective roll goods.

10 The present invention also provides a kit that can be used for preparing the retroreflective applique transfer sheets of the present invention. A typical kit includes a base sheet material (e.g., a carrier with a backing and a heat-softenable material coated thereon with optical lens elements embedded in the heat-softenable material), and a transfer adhesive composition (e.g., a vinyl chloride plastisol and an aminosilane adhesion promoter, which are supplied in separate containers such that
15 they can be mixed immediately prior to application to the base sheet material). The retroreflective properties of the applique can be supplied either in the form of a coating on the optical lens elements or as a separate container of reflective flakes for mixing with the transfer adhesive composition.

20

EXAMPLES

Retroreflective Brightness Test

The coefficient of retroreflection RA, reported in candelas per lux per square meter (cd/lux/m²), was measured using standardized test ASTM E 810-93b (1993). The entrance angle used in ASTM E 810-93b was -4° and the observation
25 angle was 0.2°.

Home Wash Laundering Durability Test

Fabrics having the samples laminated thereto were subjected to a series of home laundering tests wherein each sample was subjected to the number of wash
30 cycles stated in the tables. Each sample was washed for five consecutive cycles in a Maytag Model LS7804 automatic washing machine using the following settings:

5 "Regular" fabric (setting 10); "Large" load; and "Hot/Cold" temperature. The washing machine was attached to a temperature-controlled water supply providing an initial water temperature of about 43°C. Forty grams of a standard detergent, obtained from the American Association of Textile Chemists and Colorists (AATCC) Technical Center, P.O. Box 12215, Research Triangle, North Carolina 27709, were used for each wash cycle. After every fifth wash/rinse cycle, each sample was tumble-dried in a Maytag Model LS7804 dryer until the total load was dried using the following settings: 60°C temperature; and "Regular" fabric. Each sample was then tumbled for a 5-10 minute cooling period in the dryer with the heat
10 turned off. After each drying cycle, each sample was tested for retroreflective performance in accordance with ASTM E 810-93b.

Examples 1-39 and Comparative Examples A-BN

15 To the quantity of the selected vinyl type plastisol shown in Table 1 was added the stated quantity of the stated aminofunctional silane and the resulting mixture was stirred until homogeneous. The mixture was printed through a 110 T mesh/inch (43 T mesh/cm) polyester monofilament printing screen directly onto vapor coated sheet material (consisting of a polyester film backing covered with a heat-softenable layer of low density polyethylene having microspheres embedded
20 therein to about 30-40% of their diameters and coated with aluminum metal), which is commercially available from 3M Co. Personal Safety Products, St. Paul, MN, under the trade designation "SCOTCHLITE" Reflective Graphic Film. Immediately after printing, the printed vapor coated sheet material was heated in a "TEXAIR" Model 30 tunnel oven (available from American Screen Printing Equipment Co.,
25 Chicago, IL) with infrared panel set to 594°C, forced air thermostat set to the off position, and belt speed set to allow 28-44 seconds total internal residence time, to cause gelation of the image. When the transfer sheet returned to room temperature it was placed with the applique against a 65/35 polyester/cotton blend fabric (100 g/m² and the applique was laminated with a Hix Model N-800 heat lamination press
30 (available from Hix Corp., Pittsburg, KS) set to operate at about 174°C for about 20 seconds. The air pressure in the air line feeding the heat lamination press was set

at about 2.8 Kg/cm², which also represented the pressure at the platen. After heat lamination, the construction was allowed to return to room temperature and then the carrier (backing and heat-softenable material) was removed from the construction leaving the retroreflective applique attached to the fabric substrate.

5 The fabric bearing the substrate was laundered according to the instructions described above. Retroreflective brightness was measured according to ASTM E 810-93b as a function of number of home launderings. The results are shown in Table 1. The compositions within the scope of the present invention (Examples 1-39) displayed desirable levels of retained brightness (at least about 60% after five

10 washes, and at least about 40% after twenty-five washes). Data for similar constructions that did not contain an aminosilane (listed as 0% silane) or did not contain a sufficient amount of the aminosilane are also shown in Table 1 (Comparative Examples A-BN) and illustrate the importance of this component to the performance properties of the finished image. All data in Table 1 is the average

15 of three separate measurements.

Table 1: Brightness After Home Washing

Example	Plastisol	Mass of Plastisol (grams)	Silane	Mass of Silane (grams)	Percent Silane	Number of Washings							
						5	10	15	20	25	35	45	55
Comp. A	SX 874A		none	none	0	mean: 296 % initial: 56%	102 19%	33 6%	10 2%				
Comp. B	SX 874A	38.7	A-187	0.43	1	mean: 339 % initial: 61%	185 34%	84 15%	35 6%	11 2%			
Comp. C	SX 874A	25.8	A-187	0.53	2	mean: 322 % initial: 58%	157 29%	59 11%	23 4%	8 1%			
Comp. D	SX 874A	32.4	A-187	1.69	5	mean: 319 % initial: 57%	166 30%	82 15%	35 6%	25 4%			
Comp. E ^a	SX 874A	26.6	A-1120	0.26	1	mean: 90 % initial: 18%	5 0%						
Comp. F ^a	SX 874A	27.8	A-1120	0.56	2	mean: 139 % initial: 26%	20 4%						
I ^a	SX 874A	22.8	A-1120	1.18	5	mean: 515 % initial: 94%	476 87%	442 81%	421 77%	408 74%			
Comp. G	SX 874A	23.1	A-187 A-1120	0.48 0.47	2 2	mean: 97 % initial: 18%	46 9%	17 3%					
Comp. H	10210TF		none	none	0	mean: 147 % initial: 27%	49 9%	26 5%	20 4%				

Example	Plastisol	Mass of Plastisol (grams)	Silane	Mass of Silane (grams)	Percent Silane	Number of Washings								
							5	10	15	20	25	35	45	55
Comp. I	10210TF	30	none	none	0	mean: % initial:	43 8%	8 1%						
Comp. J	10210TF	21	A-187	0.23	1	mean: % initial:	223 41%	119 22%	63 12%	35 7%	28 5%			
Comp. K	10210TF	25.5	A-187	0.53	2	mean: % initial:	308 57%	190 35%	115 21%	78 15%	54 10%			
Comp. L	10210TF	23.6	A-187	1.17	5	mean: % initial:	371 69%	297 55%	237 44%	189 35%	150 28%			
Comp. M	10210TF	30	A-1120	0.32	1	mean: % initial:	341 63%	221 41%	149 27%	93 17%	57 11%			
2	10210TF	30	A-1120	0.92	3	mean: % initial:	561 100%	545 97%	531 95%	513 91%	487 87%	445 79%	413 74%	382 68%
3	10210TF	50	A-1120	2.55	4.85	mean: % initial:	550 98%	537 96%	528 94%	517 92%	509 91%	475 85%	447 80%	433 77%
4	10210TF	25.4	A-187 A-1120	0.51 0.53	2 2	mean: % initial:	556 99%	542 96%	523 93%	504 89%	489 87%			
Comp. N	10210TF	30	A-1100	0.3	1	mean: % initial:	264 47%	125 22%	51 9%	43 8%				
5	10210TF	30	A-1100	0.9	2.9	mean: % initial:	524 93%	465 83%	419 74%	390 69%	346 61%	272 48%	211 37%	173 31%

Example	Plastisol	Mass of Plastisol (grams)	Silane	Mass of Silane (grams)	Percent Silane	Number of Washings								
						5	10	15	20	25	35	45	55	
6	10210TF	30	A-1100	1.5	4.75	mean:	561	532	509	490	464	414	379	353
						% initial:	99%	94%	90%	87%	82%	73%	67%	62%
Comp. O	10210TF	50	A-1130	1.54	3	mean:	176	50	20					
						% initial:	32%	9%	4%					
Comp. P	10210TF	50	A-1130	2.53	4.82	mean:	356	193	107	64	47	34		
						% initial:	63%	34%	19%	11%	8%	6%		
Comp. Q	10210TF	50	A-1170	0.54	1.1	mean:	92	13	5					
						% initial:	16%	2%	0%					
7	10210TF	50	A-1170	1.5	2.9	mean:	532	458	405	359	316	206	132	88
						% initial:	93%	80%	71%	63%	55%	36%	23%	15%
8	10210TF	50	A-1170	2.51	4.8	mean:	540	513	490	466	430	378	322	284
						% initial:	97%	92%	88%	83%	77%	68%	58%	51%
Comp. R	10210TF	50	A-1106	0.5	1	mean:	25	7						
						% initial:	4%	1%						
Comp. S	10210TF	50	A-1106	1.54	3	mean:	82	18	8					
						% initial:	15%	3%	1%					
Comp. T	10210TF	50	A-1106	2.58	4.9	mean:	364	248	187	150	104	59	37	28
						% initial	67%	46%	34%	28%	19%	11%	7%	5%
Comp. U	SX 874B		none	none	0	mean:	544	493	433	379	326			
						% initial:	97%	88%	77%	67%	58%			
Comp. V ^a	SX 874B	24	A-1120	0.25	1	mean:	8							
						% initial:	1%							

Example	Plastisol	Mass of Plastisol (grams)	Silane	Mass of Silane (grams)	Percent Silane	Number of Washings									
						5	10	15	20	25	35	45	55		
Comp. W ^a	SX 874B	25.5	A-1120	0.52	2	mean: % initial:	5 0%								
Comp. X ^a	SX 874B	24.2	A-1120	1.2	5	mean: % initial:	361 65%	0 0%							
Comp. Y	SX 874B	25	A-187	0.5	2	mean:	25								
			A-1120	0.51	2	% initial:	5%								
Comp. Z	SX 864B		none	none	0	mean: % initial:	12 2%								
Comp. AA	SX 864B	27	A-187	1.4	5	mean: % initial:	17 3%								
Comp. AB	SX 864B	30.1	A-189	0.38	1.25	mean: % initial:	12 2%								
Comp. AC	SX 864B	30	A-189	0.92	3	mean: % initial:	25 5%								
Comp. AD	SX 864B	30.1	A-189	1.56	4.9	mean: % initial:	22 4%								
Comp. AE	SX 864B	20.5	A-1100	0.21	1	mean: % initial:	32 7%								
9	SX 864B	22.8	A-1100	0.68	2.9	mean: % initial:	534 97%	497 91%	462 84%	432 79%	399 73%	337 62%	274 50%	231 42%	

Example	Plastisol	Mass of Plastisol (grams)	Silane	Mass of Silane (grams)	Percent Silane	Number of Washings								
							5	10	15	20	25	35	45	55
						% initial:	100%	95%	93%	89%	86%	79%	70%	62%
11	SX 864B	20	A-1120	0.2	1	mean:	521	465	413	359	314	235	172	119
						% initial:	96%	86%	76%	66%	58%	43%	32%	22%
12	SX 864B	20.2	A-1120	0.62	3	mean:	556	531	523	505	486	457	411	386
						% initial:	102%	97%	96%	93%	89%	84%	76%	71%
13	SX 864B	26.8	A-1120	1	4	mean:	547	531	519	513	506			
						% initial:	98%	96%	93%	92%	91%			
14	SX 864B	20.2	A-1120	1	4.7	mean:	550	546	534	528	522	508	479	455
						% initial:	102%	101%	99%	97%	96%	94%	88%	84%
Comp. AF	SX 864B	20.1	A-1130	0.21	1	mean:	218	79	21					
						% initial:	40%	14%	4%					
Comp. AG	SX 864B	20.1	A-1130	0.62	3	mean:	286	127	52	29	15			
						% initial:	53%	23%	10%	5%	3%			
Comp. AH	SX 864B	20.2	A-1130	1	4.7	mean:	279	182	112	84	43			
						% initial:	51%	33%	21%	15%	8%			
15	SX 864B	33.1	A-1130	3.35	9.2	mean:	510	491	483					
						% initial:	98	95	93					
Comp. AI	SX 864B	36.7	A-1130	5.51	13	mean:	290	256	215					
						% initial:	54	47	40					
Comp. AJ	SX 864B	20	A-1170	0.2	1	mean:	77	10						
						% initial:	14%	2%						

Example	Plastisol	Mass of Plastisol (grams)	Silane	Mass of Silane (grams)	Percent Silane	Number of Washings								
						5	10	15	20	25	35	45	55	
16	SX 864B	20	A-1170	0.61	3	mean: % initial:	557 100%	536 97%	514 93%	492 89%	475 86%	447 81%	401 72%	377 68%
17	SX 864B	20	A-1170	1	4.8	mean: % initial:	447 84%	384 72%	348 65%	294 55%	239 45%	167 31%	119 22%	100 19%
Comp. AK	SX 864B	20.1	A-1106	0.25	1.2	mean: % initial:	15 3%							
Comp. AL	SX 864B	20	A-1106	0.61	3	mean: % initial:	428 79%	335 62%	254 47%	197 37%	148 27%	80 15%	50 9%	28 5%
Comp. AM	SX 864B	21	A-1106	1	4.5	mean: % initial:	463 85%	384 70%	320 59%	261 48%	210 38%	128 23%	79 14%	45 8%
Comp. AN	SX 864B		A-1310		1	mean: % initial:	26 5%							
Comp. AO	SX 864B		A-1310		2	mean: % initial:	39 7%							
Comp. AP	SX 864B		A-1310		3	mean: % initial:	20 4%							
Comp. AQ	SX 864B		A-1310		4	mean: % initial:	27 5%							
Comp. AR	SX 864B		A-1310		5	mean: % initial:	13 2%							

Example	Plastisol	Mass of Plastisol (grams)	Silane	Mass of Silane (grams)	Percent Silane	Number of Washings								
							5	10	15	20	25	35	45	55
Comp. AS	SX 864C	17.6	none	none	0	mean: % initial:	123 24%	51 10%	16 3%					
Comp. AT	SX 864C	20.4	A-1100	0.2	1	mean: % initial:	181 33%	90 16%	36 7%					
18	SX 864C	20.6	A-1100	0.61	2.9	mean: % initial:	457 84%	380 70%	320 59%	260 48%	215 40%	140 26%	86 16%	60 11%
19	SX 864C	20.2	A-1100	1	4.7	mean: % initial:	554 99%	530 94%	497 89%	473 84%	433 77%	391 70%	346 62%	287 51%
20	SX 864C	20	A-1120	0.22	1.1	mean: % initial:	511 93%	454 83%	412 75%	364 66%	334 61%	270 49%	214 39%	167 30%
21	SX 864C	20.3	A-1120	0.64	3	mean: % initial:	508 94%	474 87%	443 82%	419 77%	384 71%	338 62%	291 54%	257 47%
22	SX 864C	20	A-1120	1	4.8	mean: % initial:	505 91%	464 84%	435 79%	403 73%	384 69%	334 60%	300 54%	262 47%
Comp. AU	SX 864C	20	A-1130	0.23	1	mean: % initial:	122 22%	63 11%	38 7%					
Comp. AV	SX 864C	20.2	A-1130	0.63	3	mean: % initial:	104 19%	44 8%	20 4%					
Comp. AW	SX 864C	20	A-1130	1	4.8	mean: % initial:	34 6%	12 2%						
23	SX 864C	20.1	A-1170	0.22	1.1	mean:	518	470	419	368	319	219	130	84

Example	Plastisol	Mass of Plastisol (grams)	Silane	Mass of Silane (grams)	Percent Silane	Number of Washings								
							5	10	15	20	25	35	45	55
						% initial:	96%	87%	78%	68%	59%	41%	24%	16%
24	SX 864C	20	A-1170	0.61	3	mean:	564	542	519	494	471	424	381	340
						% initial:	102%	98%	94%	89%	85%	77%	69%	61%
25	SX 864C	20	A-1170	1	4.8	mean:	489	453	415	387	342	284	252	211
						% initial:	88%	81%	74%	69%	61%	51%	45%	38%
Comp. AX	SX 864C	20	A-1106	0.22	1.1	mean:	7							
						% initial:	1%							
Comp. AY	SX 864C	20	A-1106	0.61	3	mean:	242	132	68	59	25	9		
						% initial:	45%	24%	13%	11%	5%	2%		
Comp. AZ	SX 864C	20.6	A-1106	1.03	4.8	mean:	374	295	180	130	80	36	13	9
						% initial:	69%	54%	33%	24%	15%	7%	2%	2%
Comp. BA	Union Plus 9090	30	none	none	0	mean:	3							
						% initial:	0%							
Comp. BB	Union Plus 9090	30	A-1100	0.32	1	mean:	3							
						% initial:	0%							
Comp. BC	Union Plus 9090	30	A-1100	0.92	3	mean:	126	40	17					
						% initial:	23%	7%	3%					
Comp. BD	Union Plus 9090	30.1	A-1100	1.5	4.9	mean:	487	411	362	320	222	153	106	
						% initial:	89%	75%	66%	59%	41%	28%	19%	

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Example	Plastisol	Mass of Plastisol (grams)	Silane	Mass of Silane (grams)	Percent Silane	Number of Washings								
							5	10	15	20	25	35	45	55
Comp. BE	Union Plus 9090	30	A-1120	0.34	1.1	mean:	22	5						
						% initial:	4%	1%						
26	Union Plus 9090	20.1	A-1120	0.6	2.9	mean:	497	440	399	365	334	261	206	165
						% initial:	91%	80%	73%	67%	61%	48%	38%	30%
27	Union Plus 9090	20	A-1120	1.03	4.9	mean:	539	516	501	484	466	429	385	369
						% initial:	97%	93%	90%	87%	84%	77%	69%	67%
Comp. BF	Union Plus 9090	20.1	A-1130	0.23	1.1	mean:	24	7						
						% initial:	4%	1%						
Comp. BG	Union Plus 9090	20	A-1130	0.63	3	mean:	226	172	136	111	91	67	50	52
						% initial:	41%	31%	25%	20%	17%	12%	9%	9%
Comp. BH	Union Plus 9090	20	A-1130	1.02	4.8	mean:	258	196	183	156	141	109	87	103
						% initial:	47%	36%	34%	29%	26%	20%	16%	19%
Comp. BI	Union Plus 9090	20	A-1170	0.22	1.1	mean:	3							
						% initial:	0%							
Comp. BJ	Union Plus	20.1	A-1170	0.6	2.9	mean:	3							

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Example	Plastisol	Mass of Plastisol (grams)	Silane	Mass of Silane (grams)	Percent Silane	Number of Washings								
							5	10	15	20	25	35	45	55
	9090					% initial:	0%							
Comp. BK	Union Plus 9090	20.1	A-1170	1.02	4.8	mean:	390	261	187	120	79	30		
						% initial:	72%	48%	35%	22%	15%	5%		
Comp. BL	Union Plus 9090	20.1	A-1106	0.23	1	mean:	3							
Comp. BM	Union Plus 9090	20	A-1106	0.62	3	% initial:	0%							
						mean:	10							
						% initial:	2%							
Comp. BN	SX 863	20	none	0	0	mean:	7							
						% initial:	1%							
28	SX 863	20	A-1100	0.21	1	mean:	472	439	404	380	359	303	317	209
						% initial:	86%	80%	74%	69%	65%	55%	58%	38%
29	SX 863	20	A-1100	0.6	2.9	mean:	544	540	527	517	503	475	449	438
						% initial:	99%	98%	96%	94%	92%	87%	82%	80%
30	SX 863	20.1	A-1100	1.04	4.9	mean:	549	537	529	524	504	478	461	444
						% initial:	98%	96%	95%	94%	90%	86%	83%	79%
31	SX 863	20	A-1120	0.24	1.2	mean:	548	540	539	532	516	499	481	472
						% initial:	99%	97%	97%	96%	93%	90%	87%	85%
32	SX 863	20	A-1120	0.63	3	mean:	542	540	537	527	509	486	468	455
						% initial:	99%	98%	98%	96%	93%	88%	85%	83%

Example	Plastisol	Mass of Plastisol (grams)	Silane	Mass of Silane (grams)	Percent Silane	Number of Washings								
							5	10	15	20	25	35	45	55
33	SX 863	20	A-1120	1.02	4.8	mean:	547	531	528	521	499	470	435	419
						% initial:	99%	96%	95%	94%	90%	85%	79%	76%
34	SX 863	20.1	A-1130	0.21	1	mean:	506	491	404	365	318	256	188	135
						% initial:	92%	89%	73%	66%	58%	46%	34%	24%
35	SX 863	20.1	A-1130	0.64	3.1	mean:	453	380	341	308	261	195	129	84
						% initial:	82%	69%	62%	56%	47%	35%	23%	15%
36	SX 863	20.1	A-1130	1.05	5	mean:	392	331	312	281	251	191	147	114
						% initial:	71%	60%	57%	51%	46%	35%	27%	21%
37	SX 863	20	A-1170	0.26	1.3	mean:	548	546	535	526	509	490	470	456
						% initial:	99%	99%	97%	95%	92%	89%	85%	82%
38	SX 863	20	A-1170	0.64	3.1	mean:	551	537	532	520	501	481	451	442
						% initial:	99%	97%	96%	94%	90%	86%	81%	79%
39	SX 863	20	A-1170	1	5	mean:	534	539	527	523	504	487	473	465
						% initial:	98%	98%	96%	96%	92%	89%	86%	85%

^a "5X874A" and "5X874B" vinyl plastisols comprise approximately 3% and 6% carboxylated vinyl resin, respectively. It is believed that the amino group (A base) interacts with the acidic carboxyl groups as in a titration. The resulting species is expected to be an amine carboxylate salt and such salts, typically being water soluble, are not expected to contribute to improved wash durability of the applique transferred to a substrate.

Examples 40-41 and Comparative Examples BO-BQ

The appliques of Examples 40 and 41 were prepared as described above using 50 grams of "SX 864B" vinyl plastisol (available from Plast-O-Meric SP, Inc.) and 2.5 grams "A-1120" aminosilane (available from Osi Specialties, Inc.). The appliques were applied to a light weight 65/35 polyester/cotton blend fabric (100 g/m²) and to a heavier 65/35 polyester/cotton blend utility fabric (210 g/m²). The resulting samples were dry cleaned in a Bowe Model P525 dry cleaning machine (Bowe Passat Dry Cleaning and Laundry Machine Corp., Wichita Falls, TX) using about 90% perchloroethylene (available from Chemical Central, Dallas, TX), less than about 10% sorbitan monooleate (available from Sigma Chemical, St. Louis, MO), and less than about 10% water. The retroreflective brightness data is shown in Table 2 as a function of the number of times the samples were dry cleaned. Each entry is the average of five separate measurements. The retained brightness values increased with the number of dry cleaning operations because of the removal of organic soluble debris that typically litters the surface of the optical lens elements.

Comparative Examples BO, BP, and BQ represent appliques made according to the teachings of U.S. Patent No. 5,344,705 (Olsen). For each, a mixture of 50.0 grams of a polyester extender base available under the trade designation "NYLOBAG NB 381," 7.50 grams of an organic solvent-based retarder available under the trade designation "NYLOBAG NB RT," and 1.10 grams of an isocyanate hardener available under the trade designation "NYLOBAG NB 386," all of which are available from Sericol Group Limited, Westwood Road, Broadstairs, Kent CT10 2PA, UK, was stirred until homogeneous and then printed through a 110 T mesh/inch (43 T mesh/cm) printing screen onto the aluminum surface of the vapor coated sheet material as described above. Immediately after printing, and while the image was still wet, a uniform layer of powdered hot melt transfer adhesive 571D, available from 3M Co. Personal Safety Products, St. Paul, MN, was applied and most of the excess powdered transfer adhesive that did not adhere to the image was allowed to fall off the sheet. The resulting powdered image was

allowed to stand at room temperature overnight to dry. The resultant firm image was brushed to remove any remaining granules of the powdered transfer adhesive in the nonimaged locations. The freshly brushed images were heated in a "TEXAIR" Model 30 tunnel oven with a forced air thermostat setting of 38°C, an infrared panel setting of 505°C and set for total residence time of about 98 seconds, or enough time to cause the surface of the powdered transfer adhesive to melt. When the transfer image returned to room temperature it was placed in a Hix Model N-800 heat transfer machine with the image facing a piece of 65/35 polyester/cotton fabric (100 g/m²) and heated to 160°C for 18 seconds at 2.8 Kg/cm². When the construction returned to room temperature the carrier was removed from the construction. The samples were dry cleaned using a Speed Queen Model CD283 dry cleaning machine (Speed Queen, Ripon, WI) using perchloroethylene. These dry cleaning conditions were less vigorous and abrasive than the dry cleaning conditions used above. The retroreflective brightness values were measured after ten dry cleaning procedures were performed. For comparative Example BO the retroreflective brightness was 32; for Comparative Example BP it was 16; and for Comparative Example BQ it was 20. These are an average of two measurements. These results are only presented as raw data, however, they show the retroreflective brightness of these Comparative Examples was significantly deteriorated as a result of dry cleaning the appliques.

Table 2: Dry Cleaning Data

Brightness After Bowe Dry Cleaning (Number of Dry Cleaning Operations)												
Example	Fabric		0	1	2	3	4	5	10	15	20	25
40	65/35 Polyester/Cotton (100 g/m2)	mean:	467	489	492	492	489	489	485	480	472	464
		%	100%	103%	104%	104%	103%	103%	102%	101%	100%	99%
		Initial:										
41	65/35 Polyester/Cotton (100 g/m2)	mean:	447	482	480	486	477	483	478	473	468	464
		%	100%	106%	105%	105%	105%	105%	104%	103%	102%	101%
		Initial:										

Examples 42-43 and Comparative Examples BR-BW

These examples demonstrate that the application of an aminosilane adhesion promoter directly to the optical lens elements with a plastisol layer applied over the aminosilane layer, according to the teaching of U.S. Patent No. 4,102,562 (Harper et al.), does not provide the desired level of retained brightness. Sheets of the vapor coated sheet material bearing aluminum metal (aluminum VC) described above in Examples 1-39 or bearing Na₃AlF₆ (dielectric VC) were used in these experiments.

For the preparation of the dielectric vapor coated sheet material, the method described in U.S. Patent Nos. 3,700,305 (Bingham) and 4,763,985 (Bingham) was followed. Briefly, a web of paper coated on one side with low density polyethylene was covered on the polyethylene side with a monolayer of glass beads having a refractive index of 1.93 and a diameter ranging from 45-70 micrometers. These beads were embedded in the polyethylene to a depth of approximately 30-40 percent of their diameters by heating the web to 138°C. The exposed bead side of the web was vacuum vapor coated with Na₃AlF₆ (refractive index of 1.35-1.39) to form a first layer, then vacuum coated with Bi₂O₃ (refractive index of about 1.92) to form a second layer, both layers being about one-quarter wavelength in optical thickness, as determined at 5,500 Angstroms.

For Comparative Examples BS, BT, BV, and BW, a solution of 2.6 grams of "A-1120" aminosilane dissolved in 127 grams of 2-propanol was sprayed uniformly onto either the dielectric vapor coated sheet material or the aluminum vapor coated sheet material. The silane-treated sheets were oven dried at 66°C for two minutes. Vinyl plastisol transfer adhesive compositions containing only "SX 864B" vinyl plastisol or "SX 864B" vinyl plastisol and "A-1120" aminosilane were printed through a 110 T mesh/inch (43 T mesh/cm) polyester monofilament printing screen onto the silane-treated sheet material as well as onto the untreated vapor coated sheet material. The samples were heated to the gel point in a "TEXAIR" Model 30 tunnel oven as described above with 37 second residence times. After cooling to room temperature the images were laminated to 65/35 polyester/cotton

blend fabric (100 g/m²) as described above. Table 3 shows the effect of the various treatments on wash durability of constructions based on both types of vapor coated sheet material.

5 To test the peel force required to remove the carrier from the applique once it was laminated to a substrate, the same compositions were prepared and printed onto the vapor coated sheet materials in the image of a 4 x 25 cm rectangle. After lamination to the 65/35 polyester/cotton blend fabric described above, a peel test strip was cut from the construction measuring 2.5 cm x 25 cm. The fabric side of the construction was adhered to a similarly sized aluminum plate with double sided
10 adhesive tape. The assembly was inserted into a 90° peel force fixture in an Instron Model 1122 instrument, fitted with a 2.0 Kg load cell and adjusted to operate at 30 cm/minute. The average force measured throughout the peel was recorded for five different test strips for each example, except Comparative Example BT was the average of four measurements.

Table 3

Example	Vaporcoat Substrate	Spray	Transfer Adhesive		Average Peel Force Peel Impressions	Brightness (Number of Washings)									
			Plastisol	Silane		0	5	10	15	20	25	30	40	50	
Comp. BR	Dielectric VC	None	SX 864B alone	None	60 -- Smooth, easy, and clean peel.	Mean: 209 % of Initial: 100 %	7 4%	5 2%							
Example 42	Dielectric VC	None	SX 864B (47.6 g)	A-1120 (1.97)	106 -- Smooth, clean, easy peel leaving sharp edged image.	Mean 163 % of Initial: 100 %	171 105%	159 97%	129 79%	110 68%	92 57%	78 48%	60 37%	42 26%	
Comp. BS	Dielectric VC	A-1120	SX 864B alone	None	462 -- Hard to peel. Small areas of delamination in liner.	Mean 143 % of Initial: 100 %	89 62%	49 34%	24 17%	12 8%	20 14%	12 8%	9 6%	7 5%	
Comp. BT	Dielectric VC	A-1120	SX 864B (47.6g)	A-1120 (1.97)	371 -- Very hard to peel. Large areas of delamination in the image.	Mean: 191 % of Initial: 100 %	176 92%	150 79%	104 54%	82 43%	61 32%	49 26%	42 22%	34 18%	
Comp. BU	Aluminum VC	None	SX 864B alone	None	36 -- Very smooth, clean, very easy peel leaving uniform image. Dirty stripping.	Mean: 544 % of Initial: 100 %	51 9%	28 5%	15 3%	9 2%	5 1%				
Example 43	Aluminum VC	None	SX 864B	A-1120 (1.97g)	367 -- Very smooth, clean, and easy peel	Mean: 557 % of	539	533	527	523	517	509	508	492	

Example	Vaporcoat	Transfer Adhesive		Average Peel Force		Brightness (Number of Washings)									
	Substrate	Spray	Plastisol	Silane	Peel Impressions	0	5	10	15	20	25	30	40	50	
			(47.6g)		leaving image with sharp edges.	Initial: 100 %	97%	96%	95%	94%	93%	91%	91%	88%	

Comp. BV	Aluminum VC	A-1120	SX 864B only	None	1303 – Very hard to peel. Large peel force needed. Large portion of image stayed on liner with no transfer.	Mean: 558 % of Initial: 100 %	438	352	264	175	116	88	63	28
							79%	63%	47%	31%	21%	16%	11%	5%

Comp. BW	Aluminum VC	A-1120	SX 864B (47.6g)	A-1120 (1.97g)	1347 – Hard to peel. Not smooth, left large portions of image untransferred. Large mud cracks in image.	Mean: 585 % of Initial: 100 %	538	521	494	475	464	441	431	391
							92%	89%	84%	81%	79%	75%	74%	67%

In summary, Comparative Example BR shows the low wash durability observed when no aminosilane is applied to either the vapor coated sheet material or to the transfer adhesive composition. Example 42 used untreated dielectric vapor coated sheet material with an aminosilane-containing transfer adhesive composition according to the present invention, and the improvement in wash durability was dramatic. Comparative Example BS used the aminosilane and the vinyl plastisol of Example 42, but applied in the manner taught by U.S. Patent No. 4,102,562 (Harper et al.) wherein the dielectric vapor coated sheet material is initially coated with the aminosilane and then coated with the vinyl plastisol without an aminosilane mixed therein. Comparative Example BS showed improvement in brightness retention when compared to Comparative Example BR, but it is clearly inferior to Example 42. Furthermore, for Comparative Example BS, the carrier was difficult to remove after lamination. It required more force and often resulted in delamination and a damaged applique. Also, although Comparative Example BT, which included an aminosilane mixed with the vinyl plastisol in the transfer adhesive layer as well as a layer of the aminosilane on the vapor coated sheet material, showed improvement in brightness retention when compared to Comparative Example BS, the carrier was even more difficult to remove. When the experiments were repeated using aluminum vapor coated sheet material, similar, but more dramatic, results were obtained. For the transfer sheet having both an aminosilane coated on the vapor coated sheet material and mixed with the plastisol in the transfer adhesive layer, the carrier was difficult to remove and resulted in an unacceptable image transfer.

Examples 44-48 and Comparative Example BX

Transfer adhesive compositions were prepared using the components listed in Table 5 (Comparative Example BX was prepared as described above for Comparative Examples BO, BP, BQ). Appliques were prepared by printing these compositions through a 110 T mesh/inch (43 T mesh/cm), onto aluminum vapor coated sheet material described above in Examples 1-39, in the image of 4 cm x 25

cm rectangle. The wet images were gelled with a "TEXAIR" Model 30 tunnel oven as described above, then laminated to 65/35 polyester/cotton fabric (100 g/m²) as described above. Before peeling the carrier from these constructions, a 2.5 cm x 25 cm piece was cut from the rectangles. From the resulting pieces were cut the required number of test pieces, each measuring 2.5 cm x 5.0 cm. Stiffness was measured according to Method 5202, Federal Test Method Standard No. 191A. The results are reported as the mean bending moment at 60° deflection for the listed number of measurements made (n).

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Table 5

Example	Plastisol	Plastisol Mass (g)	Aminosilane Mass (g)	Moment Weight (lb)	n	Bending Moment (Max) N·m
44	SX 874A	103	5.1	0.02	7	4.8 x 10 ⁻⁴
45	10210T F	89.6	4.48	0.02	7	7.1 x 10 ⁻⁴
46	SX 874B	88.2	4.55	0.02	7	3.9 x 10 ⁻⁴
47	SX 864B	177	7.38	0.005	7	4.3 x 10 ⁻⁴
48	SX 863	80.0	4.00	0.005	7	2.8 x 10 ⁻⁴
Comp. BX				0.075	9	2.9 x 10 ⁻³

Examples 49-56 and Comparative Examples BY-CD

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These examples demonstrate how to prepare colored appliques which are colored under diffuse illumination and are retroreflectively white. Dielectric vapor coated sheet material was prepared as described in Examples 42-43.

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A suitable quantity of transfer adhesive composition to print the desired number of images was prepared by thoroughly mixing the components for the desired color selected from Table 6. Each of these colored plastosols was obtained under the trade designation "SX 864B" from Plast-O-Meric SP Inc. When homogeneous, the corresponding quantity of "A-1120" aminosilane was added and the resulting mixture was again stirred until homogeneous. The mixture was printed through an 110 T mesh/inch (43 T mesh/cm) polyester monofilament

printing screen directly onto the vapor coated side of the carrier that contained a transparent, dielectric mirror prepared as described above. Immediately after printing, the support sheet with the image on the dielectric mirror surface was heated in a "TEXAIR" Model 30 tunnel oven with infrared panel set to 594°C and forced air thermostat set to the off position, and belt speed set to allow 37 seconds total internal residence time, to cause gelation of the image. When the transfer sheets returned to room temperature they were placed with the image against the desired fabric and the whole was heat laminated to 65/35 polyester/cotton (100 g/m²) with a Hix Model N-800 heat lamination machine set at 174°C for 20 seconds at 2.8 Kg/cm². After heat lamination the construction was allowed to return to room temperature and then the support sheet was removed from the construction leaving the retroreflective image attached to the fabric substrate. The fabric bearing the substrate was laundered according to the example described above. Retroreflective brilliance was measured according to ASTM E 810-93b as a function of number of home launderings and the results are shown in Table 6. Data for similar constructions that do not contain an aminosilane are also shown in Table 6 and illustrate the effect on wash durability of this component. All data in Table 6 is the average of three separate measurements.

Table 6

Example	SX 864B Color	Color Mass	A-1120 Mass	A-1120 % of	Brightness (Number of Washings)							
					0	5	10	15	20	30	40	50
Comp.	magenta yellow	34.2 7.66	0	0	Means: % of 100%	202 2%	5 1%	3				
49	magenta yellow	27.8 6.24	1.74	5.1	Means: % of 100%	193 96%	185 84%	161 67%	129 54%	105 34%	66 22%	42 14%
Comp.	yellow	28.6	0	0	Means: % of 100%	208 2%	5					
50	yellow	21.3	1.1	5.2	Means: % of 100%	190 96%	184 92%	176 77%	147 64%	122 41%	79 27%	52 17%
Comp.	black		0	0	Means: % of 100%	204 2%	5					
51	black	23.2	1.2	5.2	Means: % of 100%	193 89%	172 79%	153 66%	127 53%	103 34%	65 21%	40 15%
Comp.	cyan yellow	29.7 7.7	0	0	Means: % of 100%	207 2%	5					
52	cyan yellow	23.4 6.1	1.48	5	Means: % of 100%	182 95%	174 93%	170 79%	144 66%	120 43%	78 28%	50 19%
53	strong strong yellow	23.5 6.1	1.52	5.1	Means: % of 100%	183 95%	174 93%	171 78%	122 68%	124 44%	80 30%	54 20%

Example	SX 864B	Color	A-1120	A-1120	Brightness (Number of Washings)								
	Color	Mass	Mass	% of		0	5	10	15	20	30	40	50
Comp.	cyan		0	0	Means:	209	6						
					% of	100%	3%						
54	cyan	22.9	1.1	4.8	Means:	192	190	178	145	117	75	46	30
					% of	100%	99%	93%	75%	61%	39%	24%	16%
55	strong	21.4	1.1	5.1	Means:	184	189	186	157	128	84	54	34
					% of	100%	103%	101%	85%	70%	46%	29%	19%
Comp.	Fluoresce yellow		0	0	Means:	207	5						
					% of	100%	3%						
56	Fluoresce yellow	31.9	1.59	5	Means:	190	187	187	162	142	99		49
					% of	100%	99%	99%	85%	75%	52%		26%

Example 57

To 44.7 g of "SX 864B" vinyl plastisol was added 2.24 g of "A-1120" aminosilane and the resulting mixture was stirred until homogeneous. The mixture was knife coated onto the aluminum surface of the substrate described in Examples 1-39. The freshly coated carrier material was passed through a tunnel oven set to cause gelation of the coated material. When the coated construction reached room temperature it was arranged with the coated side against a fabric substrate and the whole was laminated with a Hix Model N-800 laminator at about 174°C for about 20 seconds and at about 2.8 Kg/cm². When the laminated construction reached room temperature the carrier material was removed leaving retroreflective goods without image.

The complete disclosures of all patents, patent documents, and publications cited herein are incorporated by reference, as if individually incorporated. Various modifications and alterations may be made to the invention without departing from its spirit and scope. Accordingly, it is to be understood that the invention is not to be limited to the above-described, but is to be controlled by the limitations set forth in the following claims and any equivalents thereof. It is also to be understood that the invention may be suitably practiced in the absence of any element not specifically disclosed herein.

CLAIMS:



1. A retroreflective applique comprising a layer of optical lens elements partially embedded in and protruding from a transfer adhesive layer prepared from ingredients comprising a vinyl plastisol and a substantially nonhydrolyzed aminosilane adhesion promoter; wherein the aminosilane adhesion promoter is used in an amount effective to produce an applique capable of:
- (a) retaining at least about 60% of its initial retroreflectivity after being laminated to 65/35 polyester/cotton blend fabric (100 g/m²) at about 174°C and about 2.8 Kg/cm² pressure for about 20 seconds and subjected to home laundering conditions five times; and
- (b) retaining at least about 40% of its initial retroreflectivity after being laminated to 65/35 polyester/cotton blend fabric (100 g/m²) at about 174°C and about 2.8 Kg/cm² pressure for about 20 seconds and subjected to home laundering conditions twenty-five times.
2. The retroreflective applique of claim 1 wherein the vinyl plastisol comprises a vinyl resin made from vinyl chloride monomers.
3. The retroreflective applique of claims 1-2 wherein the vinyl resin comprises a copolymer made from monomers selected from the group consisting of vinyl chloride, vinyl acetate, vinyl ether, and mixtures thereof.
4. The retroreflective applique of claims 1-3 wherein the aminosilane adhesion promoter is selected from the group consisting of γ -aminopropyltriethoxysilane, N- β -(aminoethyl)- γ -aminopropyltrimethoxysilane, bis-trimethoxysilylpropyl amine, and H₂NCH₂CH₂NHCH₂CH₂NHCH₂CH₂CH₂Si(OCH₃)₃.



5. The retroreflective applique of claims 1-4 wherein the optical lens elements are coated with a specular reflective metal on the surface embedded in the transfer adhesive layer.
- 5 6. The retroreflective applique of claims 1-4 wherein the optical lens elements are coated with a specular reflective dielectric mirror.
7. The retroreflective applique of claims 1-6 wherein the transfer adhesive layer includes a colorant.
- 10 8. The retroreflective applique of claims 1-7 wherein the transfer adhesive layer is disposed on the optical lens elements in an imagewise fashion.
- 15 9. The retroreflective applique of claims 1-8 wherein the aminosilane adhesion promoter is selected from the group consisting of γ -aminopropyltriethoxysilane, N- β -(aminoethyl)- γ -aminopropyltrimethoxysilane, bis-trimethoxysilylpropyl amine, and $\text{H}_2\text{NCH}_2\text{CH}_2\text{NHCH}_2\text{CH}_2\text{NHCH}_2\text{CH}_2\text{CH}_2\text{Si}(\text{OCH}_3)_3$; and wherein the vinyl plastisol comprises a vinyl resin made from vinyl chloride monomers.
- 20 10. The retroreflective applique of claims 1-9 being applied to a fabric substrate.
11. An article of clothing that comprises the retroreflective applique of claims 1-10 displayed on an outer surface thereof.
- 25 12. A kit for preparing a retroreflective applique comprising:
- (a) a base sheet material comprising:
- (i) a carrier comprising a heat-resistant backing and a layer of a heat-softenable material coated thereon; and
- 30 (ii) a layer of optical lens elements partially embedded in and protruding from the heat-softenable material; and



(b) ingredients for preparation of a transfer adhesive composition comprising a vinyl plastisol and a substantially nonhydrolyzed aminosilane; wherein the aminosilane adhesion promoter is used in an amount effective to produce an applique capable of:

- 5 (i) retaining at least about 60% of its initial retroreflectivity after being laminated to 65/35 polyester/cotton blend fabric (100 g/m²) at about 174°C and about 2.8 Kg/cm² pressure for about 20 seconds and subjected to home laundering conditions five times; and
- 10 (ii) retaining at least about 40% of its initial retroreflectivity after being laminated to 65/35 polyester/cotton blend fabric (100 g/m²) at about 174°C and about 2.8 Kg/cm² pressure for about 20 seconds and subjected to home laundering conditions twenty five times.

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13. The kit of claim 12 wherein the vinyl plastisol comprises a vinyl resin made from vinyl chloride monomers; and wherein the aminosilane adhesion promoter is selected from the group consisting of γ -aminopropyltriethoxysilane, N- β -(aminoethyl)- γ -aminopropyltrimethoxysilane, bis-trimethoxysilylpropyl amine, and H₂NCH₂CH₂NHCH₂CH₂NHCH₂CH₂CH₂Si(OCH₃)₃.
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