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(54) METHOD OF PRODUCING A DYED OPTICAL COMPONENT

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(57) **ABSTRACT**

A method of producing a dyed optical component, comprises: a first step of dyeing one surface of a film made of transparent resin to produce a dyed film; and a second step of setting the dyed film in a predetermined mold and injecting the thermoplastic resin melted by heat into the mold in which the dyed film has been set to produce a dyed optical component integrally including the dyed film by film insert molding, the dyed film being set in the mold to make a dyed surface of the dyed film contact with the melted thermoplastic resin.

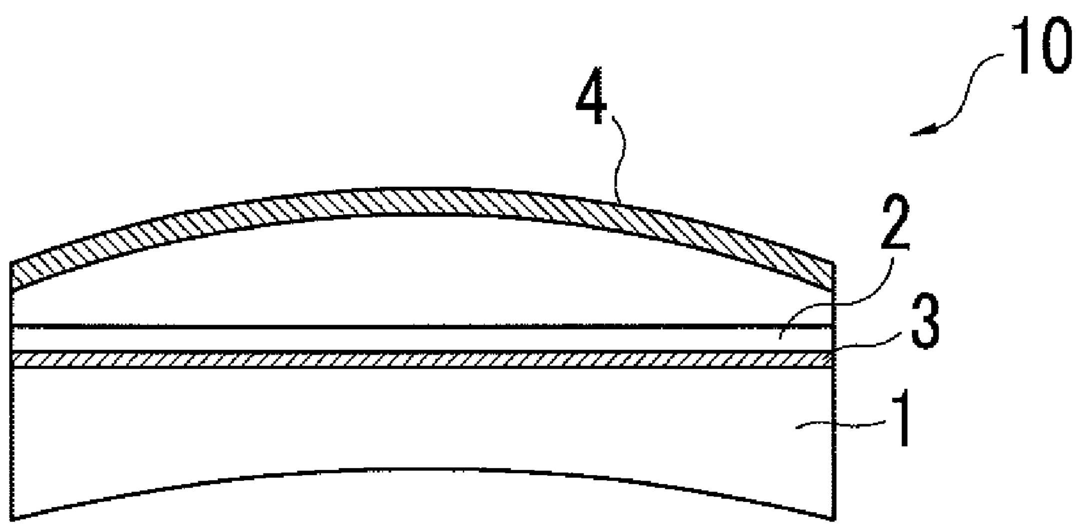


FIG. 1

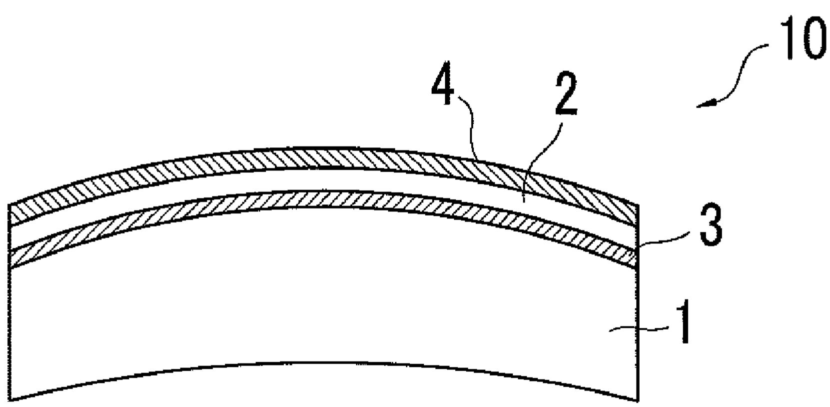


FIG. 2

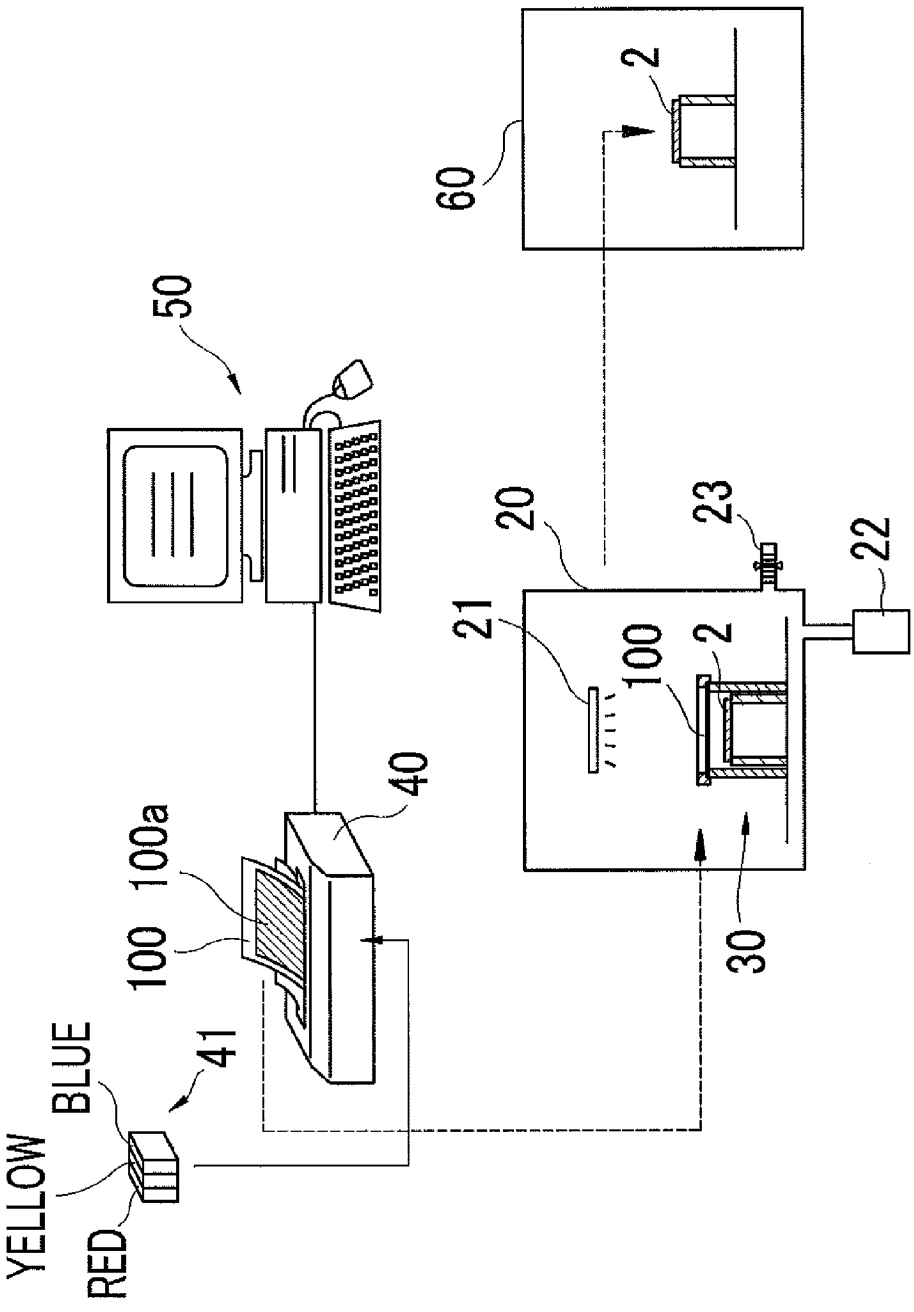
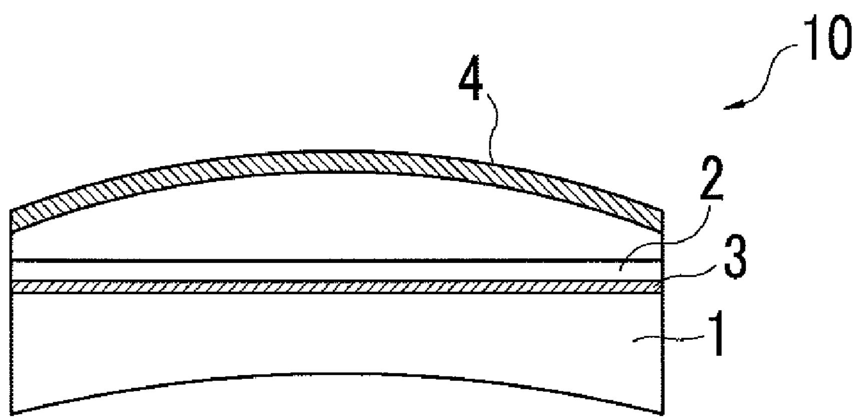


FIG. 3



METHOD OF PRODUCING A DYED OPTICAL COMPONENT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2009-134195 filed on Jun. 3, 2009, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present invention relates to a method of producing a dyed optical component to be used as sunglasses, spectacle lenses, or others.

BACKGROUND ART

[0003] There are heretofore known an optical component called a Plano lens (a lens having no diopter) and a semi-finished lens. In the semi-finished lens, a convex surface side to form a lens front surface has a predetermined optic surface and a concave surface side to form a lens rear surface is a simple concave surface that will be formed as an optic surface later by cutting. This concave surface is then appropriately cut or machined to obtain a desired diopter. On the other hand, in many cases where such semi-finished lens is to be dyed, the concave surface of the semi-finished lens is first subjected to a machining (cutting) work to have a required diopter, and the lens is immersed and dyed in a dye solution and then subjected to a hard coat treatment for lens protection (JP 2000-288891A).

SUMMARY OF INVENTION

Technical Problem

[0004] When a dyed finished lens is to be produced from the semi-finished lens as explained above, the semi-finished lens has to undergo the machining work and then the dyeing work. It therefore takes long to produce the dyed finished lens. It is also conceivable to dye the semi-finished lens in a predetermined color in advance to shorten the dyeing process and store such lens. The concave surface of the semi-finished lens is shaved or cut away, resulting in a change in color density.

[0005] In the case of applying a hard coat on the dyed semi-finished lens, the hard coat less easily adheres to a dyed surface. Particularly, the problems with adhesion and dye-affinity of the hard coat with respect to the dyed surface are important when polycarbonate is used as a lens material. Furthermore, the Plano lens, the semi-finished lens, and other lenses of such type are often mass-produced and carried in stock and also selectable dyeing patterns often have been determined in advance in order to be offered at as low a price as possible.

[0006] The present invention has been made in view of the circumstances to solve the above problems and has a purpose to provide a method of efficiently producing a dyed optical component from an optical component having been mass-produced such as a semi-finished lens and a Plano lens, the method being able to appropriately adhere a hard coat to a surface of the optical component.

Solution to Problem

[0007] To achieve the above purpose, one aspect of the invention provides a method of producing a dyed optical component, comprising: a first step of dyeing one surface of a film made of transparent resin to produce a dyed film; and a second step of setting the dyed film in a predetermined mold and injecting the thermoplastic resin melted by heat into the mold in which the dyed film has been set to produce a dyed optical component integrally including the dyed film by film insert molding, the dyed film being set in the mold to make a dyed surface of the dyed film contact with the melted thermoplastic resin.

BRIEF DESCRIPTION OF DRAWINGS

[0008] FIG. **1** is a view showing a structure of a dyed semi-finished lens with a hard coat in an embodiment;

[0009] FIG. **2** is a schematic view schematically showing a process of a vapor deposition transfer dyeing method used in the embodiment; and

[0010] FIG. **3** is a view showing a modified example of the embodiment.

DESCRIPTION OF EMBODIMENTS

[0011] A detailed description of a preferred embodiment of the present invention will now be given referring to the accompanying drawings. FIG. **1** is a view showing a structure of a semi-finished lens as a dyed optical component in this embodiment. A dyed semi-finished lens **10** includes a semi-finished lens **1** having a spherical or aspheric optical surface in a front surface (a convex surface) and a simply concave surface in a rear surface, the concave surface being to be machined later, and a dyed film **2** joined to the front surface of the semi-finished lens **1**. A joining surface of the film **2** that contacts with the semi-finished lens **1** has a dyed layer **3** dyed in a desired color. Further, an opposite surface of the film **2** from the dyed layer **3** is formed with a hard coat layer **4** for the purpose of surface protection. If the semi-finished lens does not need the surface protection, the hard coat layer **4** does not always have to be formed. The hard coat layer **4** may be a hard coat single layer or be configured in a double layer including a primer coat for enhancing adhesion and a hard coat formed on the primer coat.

[0012] As a lens material of the semi-finished lens **1**, a conventionally known thermoplastic resin may be adopted. To be concrete, polycarbonate, polyamide, polyurethane, polystyrene, acrylic resin, and others are selectable. The film **2** has only to be made of a transparent resin heretofore known and available for film insert molding. Preferably, the film **2** is made of the same material as that used for the semi-finished lens **1** or a resin having a refractive index (power) approximate to that of the lens material forming the semi-finished lens **1**. Specifically, the aforementioned materials and polyethylene terephthalate can be used. The film **2** may be configured not only in a single film form but also in a laminated film form including two or more films bonded to each other. The thickness of the film **2** is determined to be able to be so softened by heat as to firmly adhere to a metal mold. It is preferably 0.005 mm to 5 mm and more preferably 0.1 mm to 1 mm. If the thickness of the film **2** is thinner than 0.005 mm, the film **2** is likely to constrict or the like by heat.

[0013] The hard coat layer **4** formed on the front surface of the film **2** is made of a conventionally known ultraviolet curing or thermosetting hard coat solution such as an acrylic solution and a silicone solution (a siloxane solution). Such hard coat solution is applied on the front surface of the film **2** by a conventionally known method such as a brush coating technique and a spin coating technique and is subjected to a curing treatment.

[0014] A method of producing a dyed semi-finished lens in the present embodiment will be explained below. The rear surface (a surface to be joined with the semi-finished lens) of the film **2** is first dyed. The dyeing method is not particularly limited as long as it is able to dye the film **2**. However, a vapor deposition transfer dyeing method is appropriately used.

[0015] FIG. **2** is a schematic view schematically showing a process of the vapor transfer dyeing method.

[0016] Three kinds (Red, Blue, and Yellow) of vapor deposition transfer dyeing inks are individually filled in ink cartridges **41** of a commercially available inkjet printer. The cartridges filled with the inks are mounted in an inkjet printer **40** (hereinafter, referred to as a "printer") not shown. A commercially available printer may be used as the printer **40** in this embodiment. As dyes used for the vapor deposition transfer dyeing inks, sublimable dyes such as quinophthalone dyes and anthraquinon dyes are appropriately used.

[0017] To output a desired color by use of this printer **40**, hue and density of the inks to be printed on a base body are adjusted by use of a personal computer (hereinafter, referred to as a PC) **50**. The hue adjustment is made by a drawing software in the PC **50**. Accordingly, desired color data can be stored in the PC **50** and the same color tone can be obtained as many times as it is needed. Furthermore, color shade (contrast) is also digital-controlled and thus the color with the same density can be produced as many times as it is needed.

[0018] The base body on which the sublimable dye is to be printed is not particularly limited as long as it is usable in the printer **40**. For example, a commercially-available A4 paper is usable. Since the base body is heated during the vapor deposition transfer, a base body exhibiting good heat absorbing properties is preferably used.

[0019] After a base body **100** is set in the printer **40**, the PC **50** is operated to print on the base body **100** in previously selected hue and density. After printing, the base body **100** has a printed colored layer **100*a*** formed of the dyeing inks (the sublimable dyes). The size of the colored layer **100*a*** is preferably determined to be slightly larger than the outer shape of the film **2** to be used.

[0020] Subsequently, the film **2** is dyed according to the vapor deposition transfer dyeing method by using the base body **100** on which the dyeing inks have been applied. This vapor deposition transfer dyeing method is to dye a film by heating the base body **100** applied with the sublimable dyes in a vacuum atmosphere to thereby sublimate the sublimable dyes to deposit on the film placed to face the base body, and heating the film at a predetermined temperature to fix the dyes. Firstly, the base body **100** applied with the dyeing inks and the film **2** are placed in a vacuum vapor-deposition transfer machine body **20**, and the sublimable dyes contained in the dyeing inks are vaporized. The front side of the machine body **20** has a port not shown through which the base body **100** and the film **2** are taken in and out. A halogen lamp **21** is placed in the machine body **20** and used to heat the base body **100** in non-contact relation. A rotary pump **22** is used to create an almost vacuum in the machine body **20**. A leak valve **23** is to admit outside air in the machine body **20** to return the vacuum to atmospheric pressure.

[0021] A jig **30** is configured to set therein the base body **100** and the film **2**. This jig **30** includes a film holder for holding the film **2**, and a base body holder for holding the base body **100** at a predetermined interval from the film **2**. When the film **2** and the base body **100** are set in the jig **30**, a to-be-dyed surface of the film **2** and a surface of the base body **100** on the colored layer **100*a*** side face each other in non-contact relation. After setting of the film **2** and the base body **100**, the machine body **20** is sealed and evacuated to create a vacuum by the rotary pump **22**. When the vacuum in the machine body **20** reaches a predetermined level, the halogen lamp **21** is turned on to heat the base body **100** from above in non-contact relation. A heating temperature of the base body **100** is determined to be as high as possible in a range causing no degradation of the dyes and deformation of the film **2**.

[0022] Since the base body **100** is heated by turn-on of the halogen lamp **21**, the dyes sublimate and evaporate from the colored layer **100*a*** and deposit on the to-be-dyed surface of the film **2**. Heating of the base body **100** by turn-on of the halogen lamp **21** has only to be continued until almost all the dyes on the colored layer **100*a*** evaporate.

[0023] After a lapse of time in which almost all the dyes are sublimated by heat, the halogen lamp **21** is turned off. Thereafter, the leak valve **23** is opened to return the internal pressure of the machine body **20** to normal pressure and then the film **2** with the dyes deposited thereon is taken out. The sublimated dyes have been deposited on the film **2** but those dyes in this state are liable to come off the film **2**. Accordingly, the film **2** is put in an oven **60** and heated at normal pressure to fix the dyes on the film **2**. This process is performed through the steps of heating the inside of the oven at a temperature set to be as high as possible below an allowable temperature limit of the film **2**, and taking the film **2** out of the oven **60** after a lapse of a predetermined time required to obtain desired hue and density. The heating temperature of the oven **60** is preferably set to be as high as possible in a range that does not cause degradation of the dyes and deformation of the film. For example, the heating temperature is about 50° C. to about 150° C. When the film **2** is heated for the predetermined time in the oven **60**, the dyes deposited on the film **2** is fixed thereon, so that one surface of the film **2** is dyed in a desired color.

[0024] Next, a semi-finished lens joined with the dyed film **2** is produced by film insert molding. In this film insert molding, the dyed film **2** is set in a mold for semi-finished lens molding and then the lens material melted by heat is injected into the mold to unite the film **2** and the lens material. In this embodiment, a metal mold is used as the mold but not limited thereto. Any molds usable in the film insert molding can be used. The film **2** is subjected in advance to cutting and punching to have almost the same diameter and the same shape as those of the lens front surface. In the metal mold used in the molding, a wall surface for forming the lens front surface (the convex surface) is previously designed to form a predetermined optic surface. On the other hand, a wall surface of the metal mold for forming the lens rear surface (the concave surface) is designed to form a simple curved surface having no optic surface that determines the lens diopter. In such metal mold, the opposite surface of the film **2** from the dyed layer is placed in close contact with the wall surface of the metal mold to form the lens front surface. For allowing close contact with the metal mold, the film **2** is heated in advance and the softened film **2** is brought in close contact with the wall surface of the metal mold by utilizing aspiration of air. After the film **2** is placed in close contact with the metal mold, the thermoplastic lens material is poured into the metal mold and cured. Thus, a semi-finished lens joined with the dyed film **2** is produced. The produced dyed semi-finished lens includes the film **2** integrally joined to the lens front surface so that an undyed surface of the film **2** is placed as the frontmost surface of the lens.

[0025] In the dyed semi-finished lens produced as above, the undyed surface of the film **2** is the lens (the dyed semi-finished lens) front surface. Even when a hard coat having high abrasion resistance is applied on the lens front surface, that coat layer is unlikely to come off. Thus, a dyed semi-finished lens with an appropriate hard coat can be produced. The film used in this embodiment is a film having no optical function but not limited thereto. As an alternative, for example, a polarizing film may be used. Furthermore, in this embodiment, the film insert molding is conducted to join the dyed film **2** to the lens front surface but not limited thereto. For instance, the film insert molding may be performed to place a dyed film inside a semi-finished lens as shown in FIG. **3**. Moreover, in this embodiment, the film is dyed in a desired color according to the vapor deposition transfer dyeing method but not limited thereto. Any methods capable of appropriately dyeing only one surface of a film may be adopted. For instance, only one surface of the film can be dyed in such a way that the other surface of the film is covered with a mask and then the film is immersed in a dye solution. However, polycarbonate is a material very hard to dye and can hardly be dyed by normal immersion into the dye solution. In the case of using the film made of such poorly-dyable material, the aforementioned vapor deposition transfer dyeing method is particularly effective to dye the film. Although the present embodiment exemplifies the semi-finished lens, the present invention is not limited thereto and may be applied particularly appropriately to dyed optical components that can be previously prepared in large numbers in stock, e.g., a lens having no diopter (a Plano lens) used as sunglasses.

[0026] An example and a comparative example are described below but the present invention is not limited thereto.

Example 1

[0027] By using the vapor deposition transfer dyeing method, a film (380 mm×310 mm) made of polycarbonate having a thickness of 0.5 mm was subjected to dyeing to dye one surface thereof. By use of the drawing software preinstalled in the commercially available personal computer, output quantities of red, blue, and yellow inks were set to 44%, 70%, and 88% respectively. Then, an A4-size paper was printed by the printer. The inks used in this example were Red NK-1, Yellow NK-2, and Blue NK-3 each containing anthraquinon dye and being produced by Nidek Co., Ltd. The printer was PX-6250S manufactured by Seiko Epson Corporation. Sublimation and deposition of the dyes from the paper applied with the inks to the film were conducted by use of the aforementioned vacuum vapor transfer machine. As a deposition condition, a degree of vacuum was set at 0.2 kPa and the halogen lamp was continuously turned on until the heating temperature reached 230° C. on the paper. To perform a dye fixing work, the film having one surface deposited with the dyes was heated in an oven (DKN612 by Yamato Scientific Co., Ltd) at 135° C. for 2 hours.

[0028] The dyed film was punched out into a circular shape with a diameter of 78 mm. Then, the circular dyed film was placed in close contact with the wall surface of the metal mold corresponding to a lens convex surface side so that an undyed surface of the film contact with the wall surface of the metal mold. Successively, a lens material, polycarbonate, was injected into the metal mold for insert molding to produce a semi-finished lens in which the dyed film was joined to the lens front surface. The mold temperature was about 90° C. and the resin temperature was about 290° C. In order to enhance adhesion, a primer hard solution NSC-PR by Nippon Fine Chemical Co., Ltd. was applied to the front surface (the convex surface side) of the produced dyed semi-finished lens. This semi-finished lens was dried in the oven at 80° C. for 5 minutes. Then, the lens was applied with a silicone hard coat solution (NSC-5140 by Nippon Fine Chemical Co., Ltd.) and heated in the oven at 130° C. for three hours to polymerize and cure the hard coat solution, thereby forming a hard coat layer on the front surface of the semi-finished lens.

[0029] The obtained dyed semi-finished lens had a good appearance having no dyeing unevenness. The dyed semi-finished lens produced in the above process was subjected to a test according to the following method. Results of this test are shown in Table 1.

[0030] (1) Abrasion test: An abrasion test was conducted by rubbing the surface of a coat with a steel wool #0000 at five reciprocations under a load of 1500 g and observing and determining the state of that coat by the naked eyes. This determination was evaluated as follows:

[0031] ○: Almost no scratches were generated (0 to 5 scratches).

[0032] Δ: Some scratches were generated (6 to 10 scratches).

[0033] x : Many scratches were generated (more than 11 scratches).

[0034] (2) Adhesion test: An adhesion test was conducted by grooving a lens surface with a cutter to make 100 grids at intervals of 1 mm and then performing a peeling test using an adhesive cellophane tape (a cross-cut tape test) three times and examining the number of remaining grids.

Comparative Example 1

[0035] A semi-finished lens was molded of polycarbonate by use of the same metal mold as in the example 1. A front surface (a convex surface) of this semi-finished lens was directly dyed according to the vapor deposition transfer dyeing method. After dyeing, a hard coat was formed on the dyed surface. The dyeing condition and the hard coat condition were the same as those in the example 1. The produced dyed semi-finished lens had a good appearance having no dyeing unevenness. The abrasion test and the adhesion test also were conducted in the same manner as in the example 1. Results thereof are shown in Table 1.

TABLE 1

		Adhesion Test		
	Abrasion Test	1st time	2nd time	3rd time
Example 1	○	100/100	100/100	100/100
Comparative example 1	○	90/100	92/100	90/100

[0036] While the presently preferred embodiment of the present invention has been shown and described, it is to be understood that this disclosure is for the purpose of illustration and that various changes and modifications may be made without departing from the scope of the invention as set forth in the appended claims.

1. A method of producing a dyed optical component, comprising:

a first step of dyeing one surface of a film made of transparent resin to produce a dyed film; and

a second step of setting the dyed film in a predetermined mold and injecting the thermoplastic resin melted by heat into the mold in which the dyed film has been set to produce a dyed optical component integrally including the dyed film by film insert molding, the dyed film being set in the mold to make a dyed surface of the dyed film contact with the melted thermoplastic resin.

2. The method of producing a dyed optical component according to claim **1**, wherein the dyeing in the first step is performed according to a vapor deposition transfer dyeing method.

3. The method of producing a dyed optical component according to claim **2**, wherein the second step is a step of performing the film insert molding so that an, undyed surface of the dyed film forms a front surface of the optical component.

4. The method of producing a dyed optical component according to claim **3** further comprising, after the second step, a third step of forming a hard coat on the front surface of the optical component.

5. The method of producing a dyed optical component according to claim **4**, wherein the dyed optical component produced in the second step is a semi-finished lens, and the mold used in the second step is configured so that a wall surface for forming the front surface of the semi-finished lens is designed to form a predetermined optical surface and a wall surface for forming a rear surface of the semi-finished lens is designed to form a curved surface having no optic surface that determines a lens diopter.

6. The method of producing a dyed optical component according to claim **5**, wherein the thermoplastic resin used in the film insert-molding is a material selected from polycarbonate, polyamide, polyurethane, polystyrene, and acrylic resin, and a material of the film is the same material as the thermoplastic resin used in the film insert-molding.

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