

(19)



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Office européen des brevets



(11)

EP 0 690 342 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

03.01.1996 Bulletin 1996/01

(51) Int Cl.⁶: **G03C 5/17**

(21) Application number: **95304394.0**

(22) Date of filing: **22.06.1995**

(84) Designated Contracting States:
DE FR GB IT

(30) Priority: **28.06.1994 JP 146679/94**

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(54) **Composite of a silver halide photographic light-sensitive material and a radiographic intensifying screen**

(57) A composite for radiography is disclosed which essentially consists of a silver halide photographic light-sensitive material and an intensifying screen positioned on each side of the material, the material comprising a support and a silver halide photographic light-sensitive layer provided on each side of the support, wherein one of the screens has an absorption of 45% or more of a 80kVp X-ray energy, a contrast transfer function (CTF) of 0.78 or more at a space frequency of 1 line/mm and a contrast transfer function (CTF) of 0.35 or more at a

space frequency of 3 line/mm, cross-over is 5 to 15%, and the silver halide photographic light-sensitive layer on the exposed side has a sensitivity that, when the material is exposed to a monochromatic light having the same wavelength as a main emission peak wavelength of the screens and having a half band width of 15 ± 5 nm and developed, an exposure necessary to give a density of the minimum density +0.5 is 0.0060 to 0.0110 lux-sec-ond.

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Description**FIELD OF THE INVENTION**

5 The present invention relates to a new composite of a silver halide photographic light-sensitive material and a radiographic intensifying screen, and more specifically, relates to a new composite of a silver halide photographic light-sensitive material and a radiographic intensifying screen wherein sensitivity is high, an X-ray dose amount can be reduced and an X-ray image having high sharpness and excellent graininess can be obtained.

BACKGROUND OF THE INVENTION

10 In a medical radiographic photography, an image of patient tissue is formed by recording an X-ray transmission pattern on a photographic light-sensitive material (a silver halide photographic light-sensitive material) containing at least one light-sensitive silver halide emulsion layer coated and formed on a transparent support. A silver halide photographic light-sensitive material may be singly used for recording of the X-ray transmission pattern. However, since it is not desirable for a human body to be exposed to a large amount of X-ray exposure, it is ordinary that a radiographic intensifying screen is combined with a silver halide photographic light-sensitive material for radiography. The radiographic intensifying screen is provided with a fluorescent substance layer on the surface of a support. The fluorescent substance layer absorbs an X-ray radiation and converts it to visible light giving high sensitivity to the light-sensitive material. Therefore, its use can noticeably improve sensitivity of an X-ray photographing system.

As a method for further improving the sensitivity of the X-ray photographing system is developed a method that radiographs while a light-sensitive material having photographic emulsion layers on both sides, namely, a silver halide photographic light-sensitive material provided with a silver halide photographic light-sensitive layer in front of and at rear of a support is sandwiched between radiographic intensifying screens (it may be simply called an intensifying screen). Currently, in an ordinary X-ray photography, the above-mentioned photographing method is used. This method was developed because, with the use of one sheet of intensifying screen, a sufficient amount of X-ray absorption cannot be attained. Namely, when the amount of a fluorescent substance of one sheet of the intensifying screen is increased to raise the X-ray absorption, visible light, converted in the fluorescent substance layer thickened due to the increase of the fluorescent substance, is scattered and reflected inside the fluorescent substance layer. Therefore, the visible light, which is emitted from the intensifying screen and enters the light-sensitive material positioned in contact with the intensifying screen, is blurred remarkably. In addition, visible light, which occurs at the bottom of the fluorescent substance layer, has difficulty exiting the fluorescent substance layer. Therefore, even when the amount of the fluorescent substance is increased unnecessarily an effective visible light emitted from the intensifying screen is not increased. Therefore, the X-ray photographing method using 2 sheets of intensifying screens, having an appropriate thickness of fluorescent substance layer, has the advantage to increase the amount of X-ray absorption as a whole and to effectively emit visible light converted from the intensifying screen.

Various radioactive intensifying screens having various sensitivities, which range from those having a relatively thin fluorescent substance layer having high sharpness and low light-emittance to those having a relatively thick fluorescent substance layer having poor sharpness but showing high light-emittance, are commercially available.

40 In the case of a conventional highly sensitive intensifying screen, sharpness is low. When it is used in combination with a conventional highly sensitive light-sensitive material, the X-ray dosage can be reduced. However, sharpness is so poor that a sharp image can not be obtained. When cross-over of the highly sensitive light-sensitive material is extremely reduced in order to improve sharpness, poor graininess is exaggerated and an image noise is picked up, resulting in lowered diagnosis property.

45 Accordingly, in the case of chest radiography, stomach radiography, and bone radiography, in which an image quality is important, it is usual to combine low sensitivity to high sensitivity and high sharpness screen with a light-sensitive material of standard sensitivity, sacrificing an increase in the X-ray dosage. In the case of lumbar vertebra photography and cranial photography requiring high sensitivity, a high sensitivity intensifying screen and a standard to high sensitivity light-sensitive material are combined to be used, however, improvement in image quality has been demanded.

SUMMARY OF THE INVENTION

55 An object of the present invention is to provide a composite of a silver halide photographic light-sensitive material and a radiographic intensifying screen wherein sensitivity is high, the X-ray dosage amount can be reduced and an X-ray image of high sharpness and excellent graininess can be obtained.

DETAILED DESCRIPTION OF THE INVENTION

The above-mentioned object of the present invention can be attained by a composite for forming an image essentially consisting of a silver halide photographic light-sensitive material comprising a support and a silver halide photographic light-sensitive layer provided on each side of the support and a radiographic intensifying screen positioned on each side of the material, wherein at least one of the screens has an absorption of 45% or more of a 80KVp X-ray energy, a contrast transfer function (CTF) of 0.78 or more at a space frequency of 1 line/mm and a contrast transfer function (CTF) of 0.35 or more at a space frequency of 3 line/mm, crossover is 5 to 15%, and the silver halide photographic light-sensitive material has such a sensitivity that, when the material is exposed to a monochromatic light having the same wavelength as a main emission peak wavelength of the screens and having a half band width of 15 ± 5 nm, developed with the exposed material at 35°C for 25 seconds with the following developer, and the developed light-sensitive layer on the side opposite the exposed side is removed and then a density of the resulting material is measured, an exposure necessary to give a density of the minimum density + 0.5 is 0.0060 to 0.0110 lux-second,

Developer

Potassium hydroxide	21 g
Potassium sulfite	63 g
Boric acid	10 g
Hydroquinone	26 g
Triethylene glycol	16 g
5-methylbenzotriazole	0.06 g
1-phenyl-5-mercaptotetrazole	0.01 g
Glacial acetic acid	12 g
1-phenyl-3-pyrazolidone	1.2 g
Glutaraldehyde	5.0 g
KBr	4.0 g

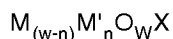
Water added to 1 liter, and pH adjusted to 10.0.

The above-mentioned silver halide photographic light-sensitive material is composed of a support and provided thereon with a hydrophilic colloidal layer located between a support and at least either of the light-sensitive layers. It is preferred that a dye layer decolorized by the above-mentioned photographic processing is further provided. When the aforesaid dye layer contains an anion dye, effects become prominent.

First of all, the radiographic intensifying screen used in the invention will be explained.

The radiographic intensifying screen is, as a basic structure, composed of a support and a fluorescent substance layer provided on one side of the support. The fluorescent substance layer is a layer wherein a fluorescent substance is dispersed in a binding agent (binder). Incidentally, on the side of this support opposite to that of the fluorescent substance layer (a surface not facing a support), a transparent layer is ordinarily provided so that it protects the fluorescent substance layer from chemical degeneration and physical shock.

The preferable as a fluorescent substance used for the radiographic intensifying screen is one represented by the following Formula:



wherein M represents at least one of metallic yttrium, lanthan, gadolinium or lutetium; M' represents at least one of rare earth elements, preferably cerium, dysprosium, erbium, europium, holmium, neodymium, praseodymium, samarium, terbium, thulium or ytterbium; X represents an intermediate chalcogen (S, Se or Te) or a halogen atom; n is 0 when w is 1 or n is 0 or 1 when w is 2; and w is 1 when X represents a halogen atom or w is 2 when X represents a chalcogen.

As practical examples of preferable fluorescent substances for the radiographic intensifying used in the radiographic intensifying screen of the present invention, the following fluorescent substances may be cited.

Terbium-activated rare earth oxysulfide fluorescent substances [$\text{Y}_2\text{O}_2\text{S:Tb}$, $\text{Gd}_2\text{O}_2\text{S:Tb}$, $\text{La}_2\text{O}_2\text{S:Tb}$, (Y , Gd) $_2\text{O}_2\text{S:Tb}$, (Y , Gd) $_2\text{O}_2\text{S:Tb}$, Tm etc.], terbium-activated rare earth oxyhalide fluorescent substances (LaOBr:Tb , LaOBr:Tb , Tm , LaOCl:Tb , Tm , GdOBr:Tb , GdOCl , etc.) and thulium-activated rare earth oxyhalide fluorescent substances (LaOBr:Tm , LaOCl:Tm , etc.).

As the most preferable fluorescent substance used for the radiographic intensifying screen of the present invention in the above-mentioned fluorescent substance, terbium-activated gadolinium oxysulfide type fluorescent substance can be cited. U.S.P. No. 3,725,704 describes terbium-activated gadolinium oxysulfide type fluorescent substances in detail.

The fluorescent substance layer is ordinarily coated on a support utilizing a coating method under an ordinary pressure as described below. Namely, particle fluorescent substance and a binder are mixed and dispersed in a solvent for preparing a coating solution. This coating solution is directly coated on a support of a radiographic intensifying screen under an ordinary pressure by the use of a coating means such as a doctor blade, roller coater and a knife coater. Following this, by removing the solvent from the coated layer, the fluorescent substance layer is coated on the support. Otherwise, the coating solution is coated on a tentative support such as a glass plate under an ordinary pressure. Next, the solvent is removed from the coated layer so that a resin thin layer containing a fluorescent substance is formed. By removing this from the tentative support and jointing on a support of a radiographic intensifying screen, the fluorescent substance layer is coated onto the support.

It is desirable that the radiographic intensifying screen used in the present invention is produced by the use of a thermoplastic elastomer as a binder as described hereafter and by increasing the filling ratio (in other words, reducing the ratio of void in the fluorescent substance layer) by means of a compression processing.

Intensification of a radiographic intensifying screen is basically dependent on the total emission amount of a fluorescent substance contained in a panel. This total emission amount varies depending upon not only emission illuminance of the fluorescent substance itself but also the content of the fluorescent substance in the fluorescent substance layer. That the content of fluorescent substance is large also means that the absorption of a radiation such as an X-ray is also large. Therefore, higher sensitivity can be obtained and an image quality (especially, graininess) is improved. On the other hand, when the content of the fluorescent substance in the fluorescent substance layer is constant, the more the fluorescent substance particles are filled densely, the more the layer thickness can be reduced. Therefore, spreading of emitted light due to scattering can be reduced so that relatively high sharpness can be obtained.

For producing the above-mentioned radiographic intensifying screen, it is preferable to produce it by a production method including

- a) a step forming a fluorescent substance sheet composed of a binder and a fluorescent substance
- b) a step providing the above-mentioned fluorescent substance sheet on a support and adhering the above-mentioned fluorescent substance sheet on the support while compressing at a softening temperature or melting point or more of the above-mentioned binder.

First of all, step a) will be explained. The fluorescent substance sheet which is a fluorescent substance layer of a radiographic intensifying screen can be produced by coating a coating solution, wherein a fluorescent substance is dispersed uniformly in a binder solution, on a tentative support for forming the fluorescent substance sheet, drying and peeling it off from the tentative support. Namely, first of all, a binder and fluorescent substance particles are added to an appropriate organic solvent and then, stirred to prepare a coating solution wherein the fluorescent substance is dispersed uniformly in the binder solution.

As a binder, a thermoplastic elastomer whose softening temperature or a melting point is 30 to 150°C is used singly or in combination with other binder polymers. The thermoplastic elastomer has elasticity at room temperature and has fluidity when heated. Therefore, it can prevent damage of the fluorescent substance due to pressure in compression. As examples of a thermo-plastic elastomer, polystyrene, polyolefin, polyurethane, polyester, polyamide, polybutadiene, ethylene vinyl acetate copolymer, poly vinyl chloride, natural rubbers, fluorine-containing rubbers, polyisoprene, chlorinated polyethylene, styrene-butadiene rubbers and silicone rubbers are cited. The component ratio of thermoplastic elastomer in the binder is allowed to be 10 wt% or more and 100 wt% or less. However, it is desirable that the binder is composed of the thermo-plastic elastomer as much as possible, especially is composed of a thermo-plastic elastomer of 100 wt%.

As examples of a solvent for preparing a coating solution, lower alcohols such as methanol, ethanol, n-propanol and n-butanol; chlorine-containing hydrocarbons such as methylenechloride and ethylenechloride; ketones such as acetone, methyl ethyl ketone and methyl isobutyl ketone; esters of lower fatty acids and lower alcohols such as methyl acetate, ethyl acetate and butyl acetate; ethers such as dioxane, ethyleneglycol monoethylether and ethyleneglycol monomethylether and their mixtures can be cited. The mixture ratio between the binder and the fluorescent substance in the coating solution varies depending upon the characteristic of the radiographic intensifying screen and the kind of fluorescent substance. Generally, the mixture ratio of the binder and the fluorescent substance is from 1:1 to 1:100 (by

weight), and preferably from 1:8 to 1:40 (by weight).

Various additives such as a dispersant for improving dispersing property of a fluorescent substance in aforesaid coating solution and a plasticizer for improving binding force between a binder and a fluorescent substance in the fluorescent substance layer after being formed may be mixed. Examples of a dispersant used for the above-mentioned purpose include phthalic acid, stearic acid, caproic acid and lipophilic surfactants may be cited. Examples of a plasticizer include phosphates such as triphenyl phosphate, tricresyl phosphate and diphenyl phosphate; phthalates such as diethyl phthalate and dimethoxyethyl phthalate; ester glycols such as ethylphthalylethyl glycolate and butylphthalylbutyl glycolate; and polyesters of polyethylene glycols and aliphatic dibasic acids such as polyester of triethylene glycol and adipic acid and polyester between diethylene glycol and succinic acid are cited. Next, the coating layer is formed by coating the coating solution containing the fluorescent substance and the binder prepared in the above-mentioned manner on the tentative support for forming a sheet uniformly. This coating operation can be conducted by the use of a conventional means such as a doctor blade method, a roll coater method and a knife coater method.

A material of the tentative support can be selected from glass, metal plate or conventional materials as a support for an intensifying screen of X-ray. Examples of such materials include plastic films such as cellulose acetate, polyester, polyethylene terephthalate, polyamide, polyimide, triacetate and polycarbonate, metallic sheets such as aluminium foil and aluminium alloy foil, an ordinary paper, baryta paper, resin-coated paper, pigment paper containing a pigment such as titanium dioxide, paper wherein polyvinyl alcohol is subjected to sizing, ceramic plates or sheets such as alumina, zirconia, magnesia and titania. A coating solution for forming the fluorescent substance layer is coated on the tentative support and dried. Following this, the coating layer is peeled off from the tentative support so that the fluorescent substance sheet which will be a fluorescent substance layer of a radiographic intensifying screen is formed. Therefore, it is desirable that a mold-releasing agent is coated on the surface of the tentative support and that the fluorescent substance sheet formed is easily peeled off from the tentative support.

Next, step b) will be explained. First of all, a support for a fluorescent substance sheet prepared in the above-mentioned manner is prepared. This support can be selected arbitrarily from the same materials as those used for a tentative support used in forming the fluorescent substance sheet.

In a conventional radiographic intensifying screen, in order to strengthen binding between a support and a fluorescent substance layer and in order to improve sensitivity or image quality (sharpness and graininess) as the radiographic intensifying screen, it is known to coat a polymer substance such as gelatin as an adhesive layer on the surface of a support on the side of the fluorescent substance layer or to provide thereon a light-reflection layer comprising a light-reflective substance such as titanium dioxide or a light-absorption layer comprising a light-absorptive substance such as carbon black. The support used in the present invention may be provided with each of the above-mentioned layer. The constitution may be arbitrarily selected depending upon the purpose and application of the desired radiographic intensifying screen. The fluorescent substance sheet obtained through step a) is loaded on a support. Next, the fluorescent substance sheet is stuck on the support while compressing it at a softening temperature or a melting point or higher of the binder.

In the above-mentioned manner, by the use of a method that compress the fluorescent substance sheet without fixing it on the support in advance, the sheet can be spread thinly. Accordingly, it prevents damage of the fluorescent substance. In addition, compared to a case wherein the sheet is fixed for being pressed, a higher fluorescent substance filling rate can be obtained even with the same pressure. Examples of a compressor used for compressing processing of the present invention include conventional ones such as a calender roll and a hot press. In compression processing by the use of the calender roll, the fluorescent substance sheet obtained through step a) is loaded on the support, and then, the sheet is passed through rollers heated to the softening temperature or the melting point of the binder or higher at a certain speed. However, a compressor used for the present invention is not limited thereto. Any compressing means can be used, provided that it can compress the sheet while heating it. The compression pressure is preferably 50 kg/cm² or more.

In an ordinary radiographic intensifying screen, a transparent protective layer is provided for protecting the fluorescent substance layer physically and chemically on the surface of the fluorescent substance layer opposite to that being in contact with the support, as described before. Such a protective layer is preferably provided in the radiographic intensifying screen of the present invention. Layer thickness of the protective layer is ordinarily in a range from about 0.1 to 20 μm . The transparent protective layer can be formed by a method that coats a solution prepared by dissolving a transparent polymer such as cellulose derivatives including cellulose acetate and nitro cellulose; and a synthetic polymer including polymethyl methacrylate, polyvinyl butylal, polyvinyl formal, polycarbonate, polyvinyl acetate, vinyl chloride-vinyl acetate copolymer on the surface of the fluorescent substance layer. In addition, the transparent protective layer can also be formed by a method that forms a sheet for forming a protective layer such as a plastic sheet composed of polyethylene terephthalate, polyethylene naphthalate, polyethylene, polyvinylidene chloride or polyamide; and a protective layer forming sheet such as a transparent glass plate is formed separately and they are stuck on the surface of the fluorescent substance layer by the use of an appropriate adhesive agent.

As a protective layer used for the radiographic intensifying screen of the present invention, a layer formed by a

coating layer containing an organic solvent soluble fluorescent resin is preferable. As a fluorescent resin, a polymer of a fluorine-containing olefin (fluoro olefin) or a copolymer of a fluorine-containing olefin is cited. A layer formed by a fluorine resin coating layer may be cross-linked. When a protective layer composed of a fluorine resin is provided, dirt exuded from a film in contacting with other materials and an X-ray film is difficult to come into inside of the protective layer. Therefore, it has an advantage that it is easy to remove dirt by wiping. When an organic solvent soluble fluorescent resin is used as a material for forming a protective layer, it can be formed easily by coating a solution prepared by dissolving this resin in a suitable solvent and drying it. Namely, the protective layer is formed by coating the protective layer forming material coating solution containing the organic solvent soluble fluorine resin on the surface of fluorescent layer uniformly by the use of the doctor blade and by drying it. This formation of a protective layer may be conducted concurrently with the formation of the fluorescent substance layer by the use of multilayer coating.

The fluorine resin is a homopolymer or copolymer of a fluorine containing olefin (fluoroolefin). Its examples include polytetrafluoroethylene, polychlorotrifluoroethylene, polyvinyl fluoride, polyvinylidene fluoride, tetrafluoroethylene-hexafluoropropylene copolymer and fluoroolefin-vinyl ether copolymer. Though fluorine resins are insoluble in an organic solvent, copolymers of fluoroolefins as a copolymer component are soluble in an organic solvent depending upon other constituting units (other than fluoroolefin) of the copolymers. Therefore, the protective layer can be formed easily by coating a solution wherein the aforesaid resin is dissolved in a suitable solvent for preparing on the fluorescent substance layer to be dried. Examples of the above-mentioned copolymers include fluoroolefin-vinylether copolymer. In addition, polytetrafluoroethylene and its denatured product are soluble in a suitable fluorine-containing organic solvent such as a perfluoro solvent. Therefore, they can form a protective layer in the same manner as in the copolymer containing the above-mentioned fluoroolefin as a copolymer component.

To the protective layer, resins other than the fluorine resin may be incorporated. A cross-linking agent, a hardener and an anti-yellowing agent may be incorporated. However, in order to attain the above-mentioned object sufficiently, the content of the fluorine resin in the protective layer is suitably 30 wt% or more, preferably 50 wt% or more and more preferably 70 wt% or more. Examples of resin incorporated in the protective layer other than the fluorine resin include a polyurethane resin, a polyacrylic resin, a cellulose derivative, polymethylmethacrylate, a polyester resin and an epoxy resin.

The protective layer for the radiographic intensifying screen used in the present invention may be formed by either of an oligomer containing a polysiloxane skeleton or an oligomer containing a perfluoroalkyl group or by both thereof. The oligomer containing the polysiloxane skeleton has, for example, a dimethyl polysiloxane skeleton. It is preferable to have at least one functional group (for example, a hydroxyl group). In addition, the molecular weight (weight average) is preferably in a range from 500 to 100000, more preferably 1000 to 100000, especially more preferably 3000 to 10000. In addition, the oligomer containing the perfluoroalkyl group (for example, a tetrafluoroethylene group) preferably contains at least one functional group (for example, a hydroxyl group: -OH) in a molecule. Its molecular weight (weight average) is 500 to 100000, more preferably 1000 to 100000 and especially preferably 10000 to 100000. When an oligomer containing a functional group is used, cross-linking reaction occurs between the oligomer and a resin for forming a protective layer in forming the protective layer so that the oligomer is taken into a molecule structure of the layer-forming resin. Therefore, even when the X-ray conversion panel is used for a long time repeatedly or cleaning operation of the surface of the protective layer is carried out, the oligomer is not taken off from the protective layer. Therefore, the addition of the oligomer becomes effective for a long time so that use of the oligomer having a functional group becomes advantageous. The oligomer is contained in the protective layer preferably in an amount of 0.01 to 10 wt% and especially 0.1 to 2 wt%.

In the protective layer, perfluoro olefin resin powder or silicone resin powder may be added. As the perfluoro olefin resin powder or the silicone resin powder, those having an average particle size of preferably 0.1 to 10 μm , and more preferably 0.3 to 5 μm . The above-mentioned perfluoro olefin resin powder or the silicone resin powder is added to the protective layer preferably in an amount of 0.5 to 30 wt% and more preferably 2 to 20 wt% and especially preferably 5 to 15 wt%.

As described above, the radiographic intensifying screen used in the present invention has high sensitivity, wherein the contrast transfer function (CTF) is 0.78 or more in terms of one spatial frequency/mm and 0.35 or more in terms of three spatial frequency/mm.

Next, the silver halide photographic light-sensitive material of the invention will be explained. The silver halide photographic light-sensitive material of the invention comprises a support and a silver halide photographic light-sensitive layer provided on each side of the support, wherein at least one of the light-sensitive layers has such a sensitivity that, when the material is exposed to a monochromatic light having the same wavelength as a main emission peak wavelength of the above described screen and having a half band width of 15 ± 5 nm, developed with the exposed material at 35°C for 25 seconds with the above described developer, and the developed light-sensitive layer on the side of the support opposite the exposed side is removed and a density of the removed layer is measured, an exposure necessary to give a density of the minimum density + 0.5 is 0.0060 to 0.0110 lux-second, and the light-sensitive layer on the side of the support opposite a radiographic intensifying screen positioned in contact with the light sensitive material has an

cross-over of 5 to 15% of an emission light of the radiographic intensifying screen.

In a method that measures sensitivity of a silver halide photographic light-sensitive material, the wavelength of an exposure light-source used must be the same or substantially the same as that of the main emission peak of a radiographic intensifying screen used in combination. For example, when a fluorescent substance of a radiographic intensifying screen is terbium-activated gadolinium oxy sulfide, the wavelength of the main emission peak is 545 nm, so that the light-source used when the sensitivity of the silver halide photographic light-sensitive material is measured should have a main emission wavelength of 545 nm. As a method that obtains a monochromatic light, a method that uses a filter system which combines interference filters can be utilized. According to this method, a monochromatic light having a necessary amount of exposure and a half band width of 15 ± 5 nm can ordinarily be obtained easily though it depends upon a combination with an interference filter. Incidentally, it can be said that the spectral sensitivity of the silver halide photographic light-sensitive material is continuous and its sensitivity is not changed within the wavelength of 15 ± 5 nm regardless whether or not it is subjected to spectral sensitization processing. Examples of exposure light-source include a system combining a tungsten light-source (its color temperature is 2856°K) with an interference filter having a transmission maximum of 545 nm, when the fluorescent substance of a radiographic intensifying screen used in combination is terbium-activated oxy sulfide.

The silver halide photographic light-sensitive material used in the invention, when developed with the above described developer at 35°C for 25 seconds, has a γ value of preferably 1.8 to 3.2 wherein the γ value represents a contrast from the minimum density plus 0.25 to the minimum density plus 2.0. Further, a γ value from density 1.0 to density 2.0 is preferably 2.7 to 4.2.

For the measurement of crossover one sheet intensifying screen is used. The intensifying screen is positioned in contact with a photographic light-sensitive material having a light-sensitive layer on each side of a support, and then a black paper is positioned in contact with the photographic light-sensitive material on the side of the support opposite the intensifying screen. Thereafter, the resulting composite material is exposed to an X-ray from the black paper side varying an X-ray exposure by changing a distance between target of an X-ray radiation source and the intensifying screen. The exposed material is developed and then divided into two portions. In the one portion the light-sensitive layer (a light-sensitive layer on the back side), which was in contact with the intensifying screen, is peeled off and in the other portion, the light-sensitive layer (a light-sensitive layer on the front side), which was in contact with the black paper, is peeled off. Subsequently, densities of the resulting materials are measured and plotted against the exposures to obtain characteristic curves. The average value $\overline{\Delta \log E}$ of sensitivity difference $\Delta \log E$ between each sensitivity in each straight line portion of the above obtained curves is calculated. Then, crossover is calculated from the following equation:

$$\text{Crossover (\%)} = 100 / \text{antilog}(\overline{\Delta \log E}) + 1$$

The representative silver halide photographic light-sensitive material used in the invention comprises a blue-colored transparent support and provided on each side of the support, a subbing layer, a dye layer for reducing crossover, at least one light-sensitive silver halide emulsion layer and a protective layer in this order. Each layer on each side of the support is preferably the same as each other.

The support is made of a transparent material such as polyethyleneterephthalate, and colored by a blue dye. As the blue dye can be used various dyes such as anthraquinone type dyes known as colorants for an X-ray film. The thickness of the support may be optionally selected from a range of 160 to 200 μm . A subbing layer composed of a water soluble polymer such as gelatin may be provided on the support in the same manner as in an ordinary X-ray film.

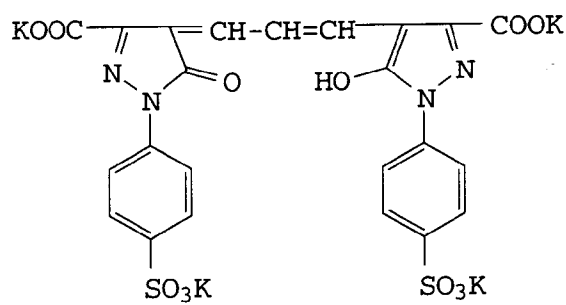
On the subbing layer is preferably provided a dye layer for reducing crossover. It is preferable that the dye layer is ordinarily a colloid layer containing a dye and is decolorized in the photographic processing as above described. It is also preferable that the dye is fixed to the lower portions of the dye layer so that it does not diffuse to the upper light-sensitive silver halide emulsion or protective layer.

Various methods for promoting decoloration and fixing a dye in the dye colloidal layer are known. There are, for example, a method using a combination of a cationic mordant and an anionic dye as described in EP Patent Publication No. 211273B1, a method using a combination of an anionic dye and a polymer dispersion as a mordant obtained by polymerizing an ethylenically unsaturated monomer having an anionic functional group in the presence of a cationic mordant as described in Japanese Patent O.P.I. Publication No. 2-207242, and a method using a solid fine crystal dye (fine crystalline dye particles). Of these methods the method using a solid fine crystal dye is preferable. The above dye layers are effective for obtaining crossover of 15 to 5%.

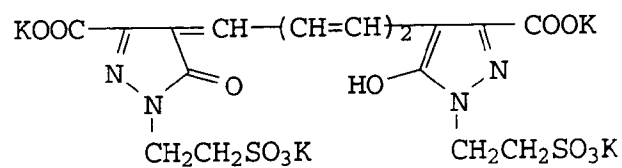
The dye content of the dye layer which varies due to kinds of dyes is an amount necessary to give crossover of 5 to 15%, and preferably 25 to 80 mg per m^2 on one side of light sensitive material.

Examples of anionic dyes used when a cationic mordant and an anionic dye are combined for forming a dye layer will be shown below.

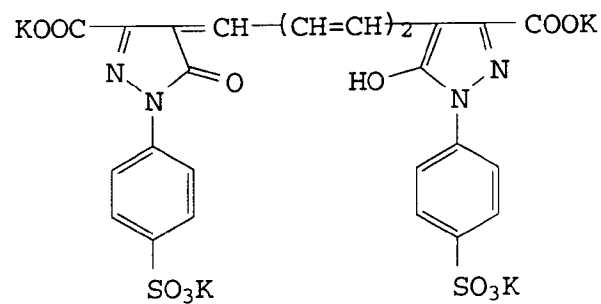
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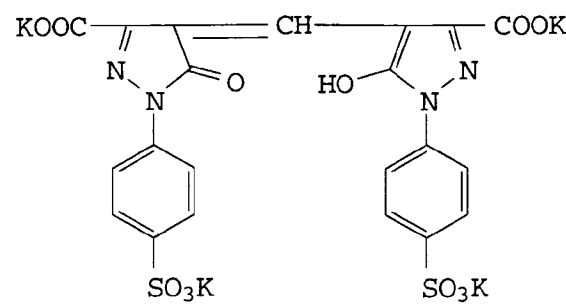
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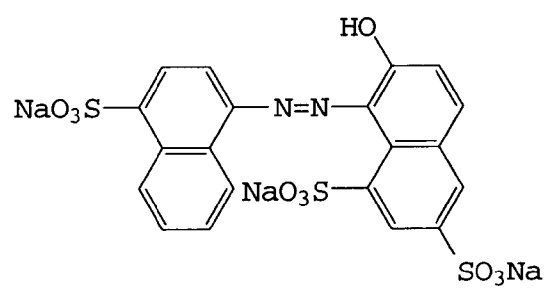
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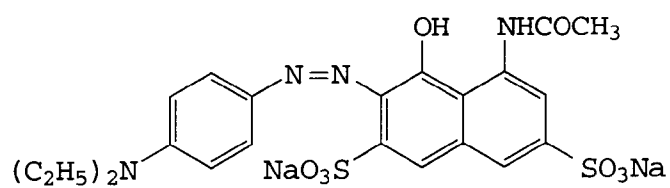
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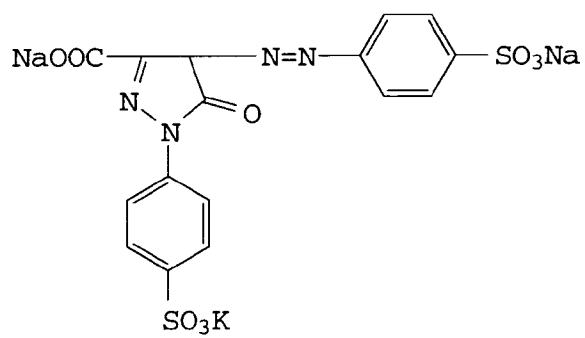
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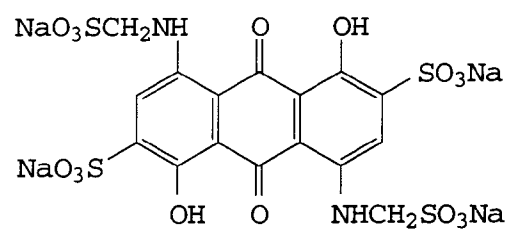
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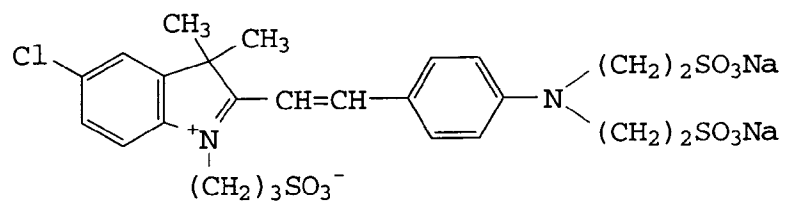
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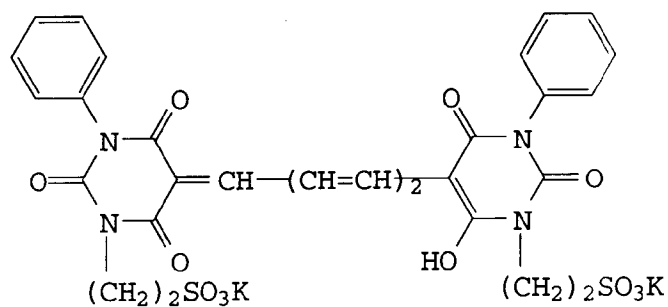
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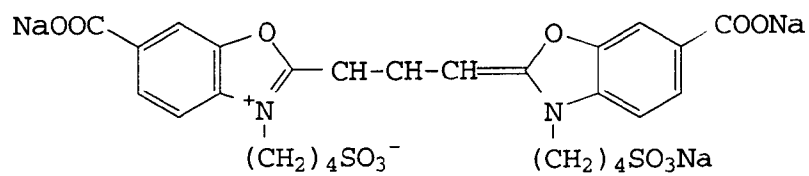
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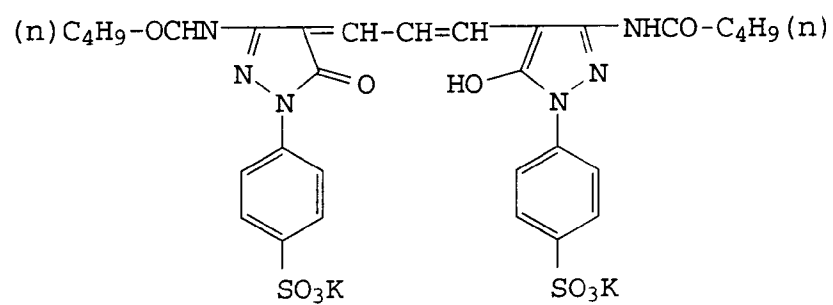
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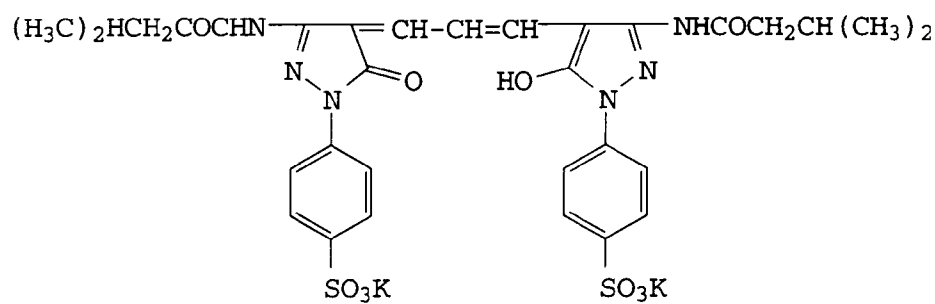
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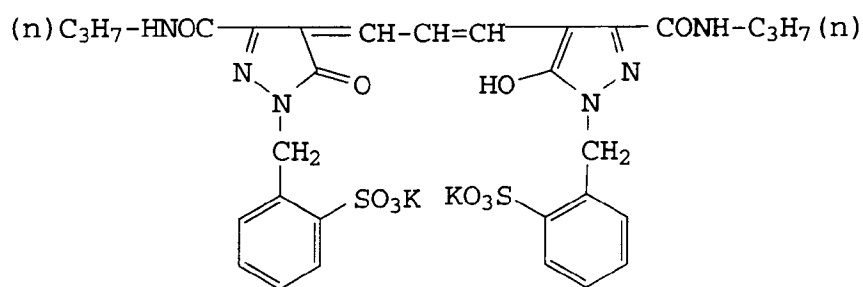
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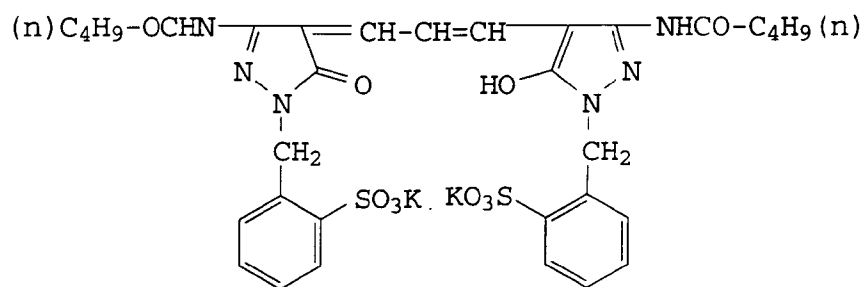
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(14)

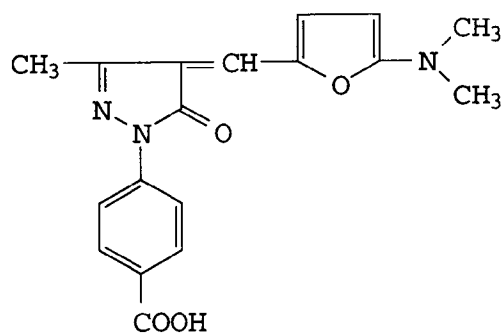


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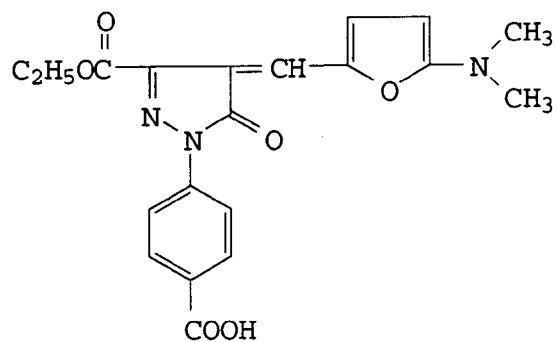


Examples of dyes used in a dye layer in the form of solid fine crystals are as follows:

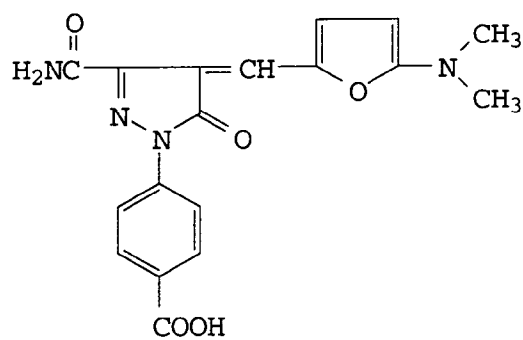
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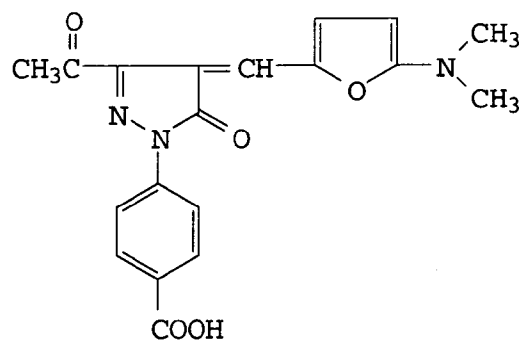
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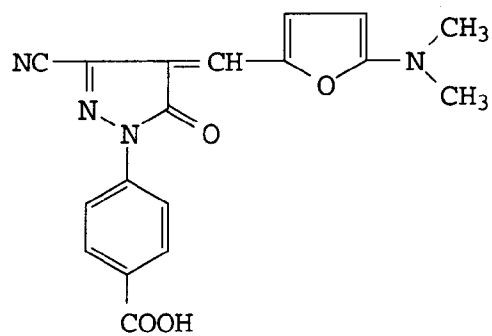
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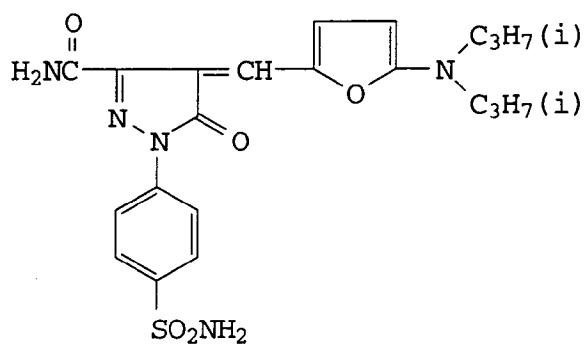
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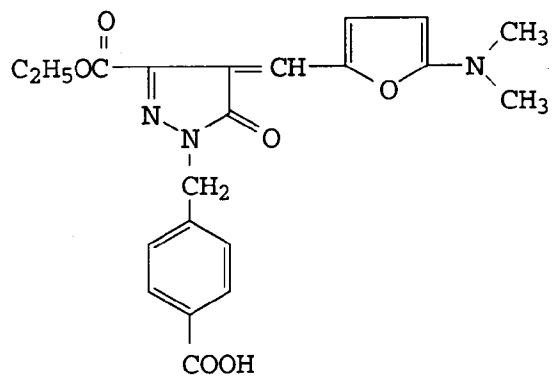
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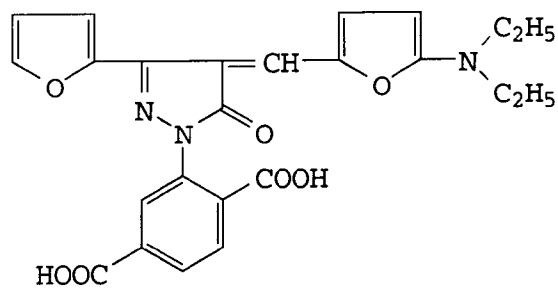
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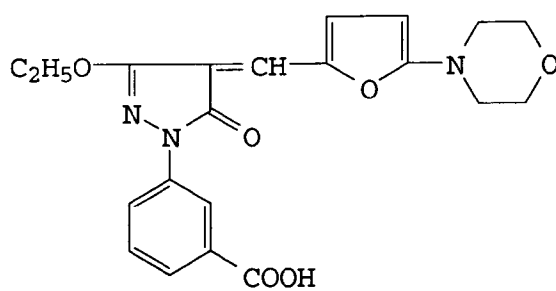
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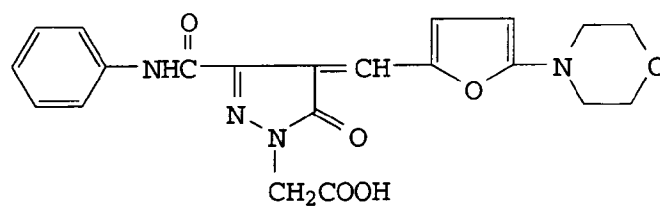
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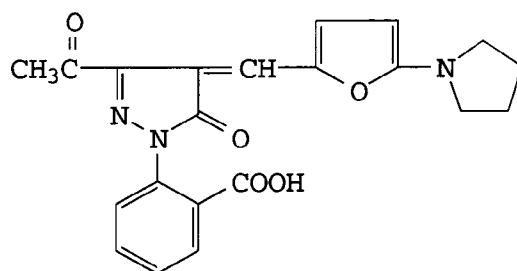
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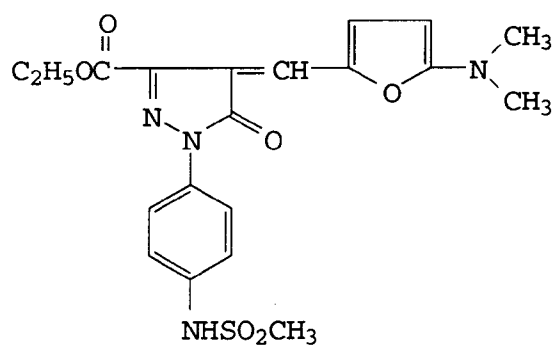
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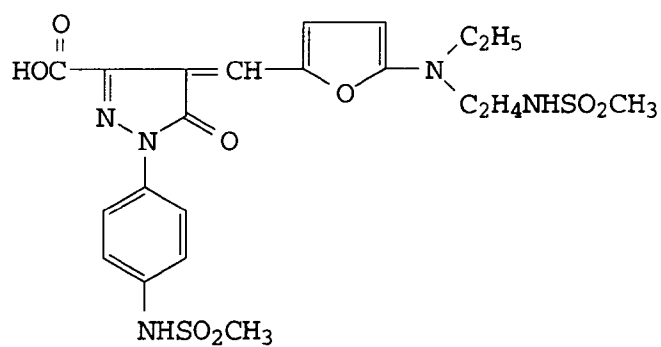
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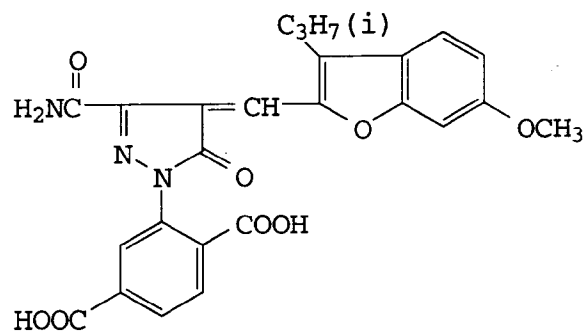
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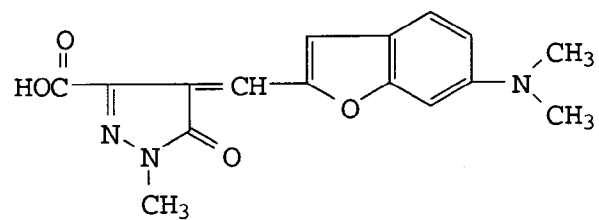
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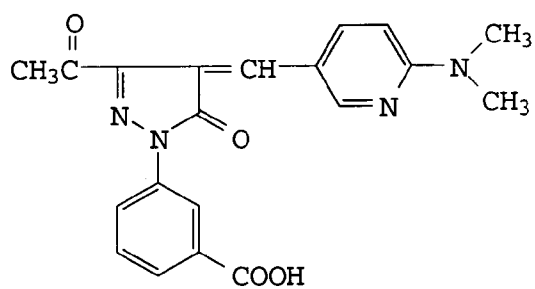
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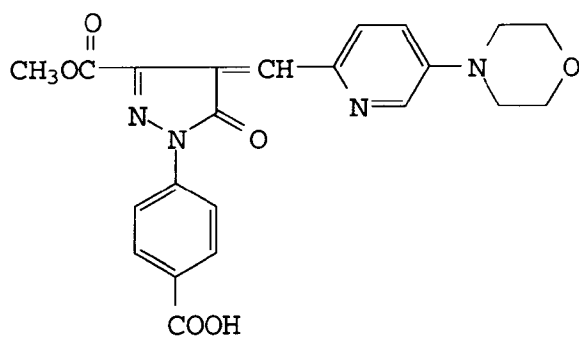
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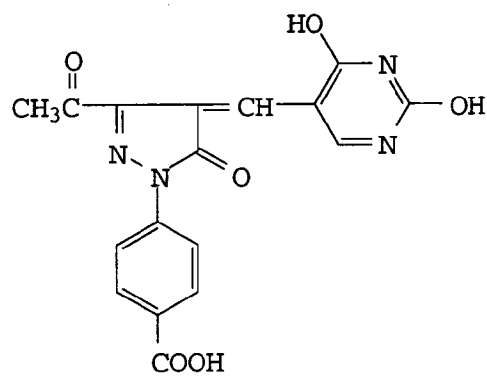
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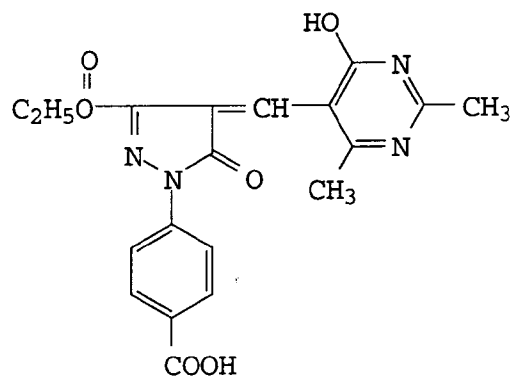
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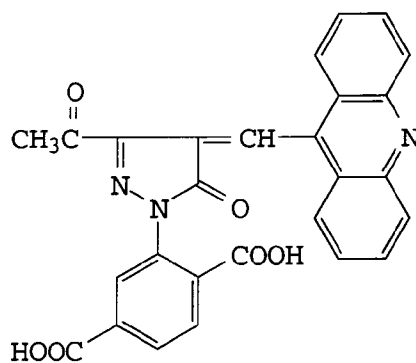
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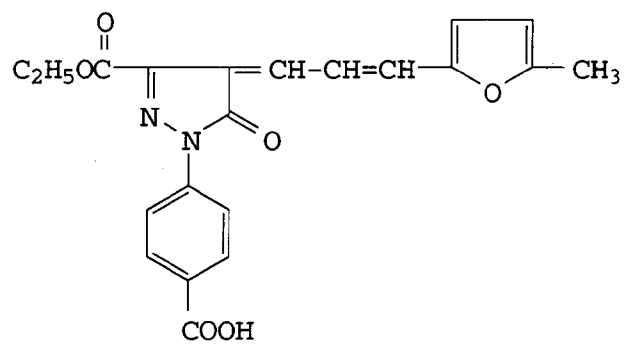
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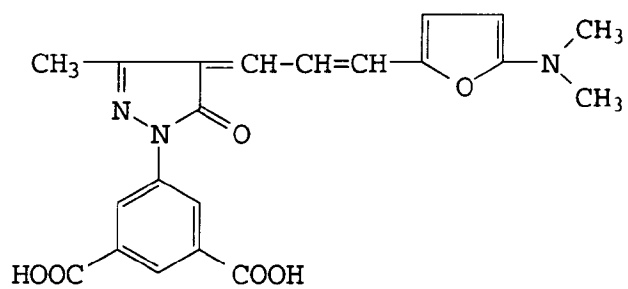
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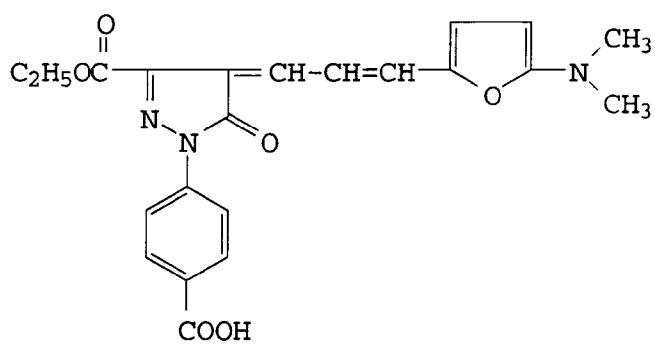
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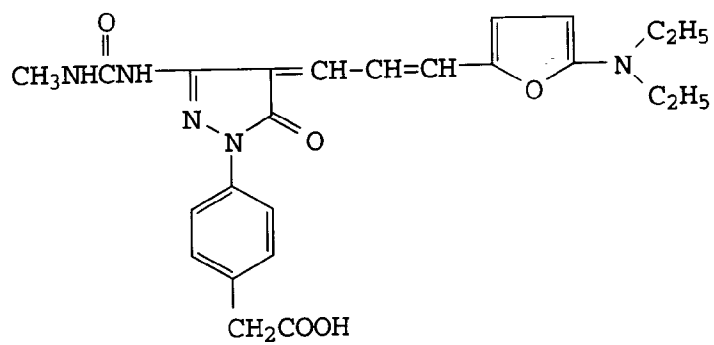
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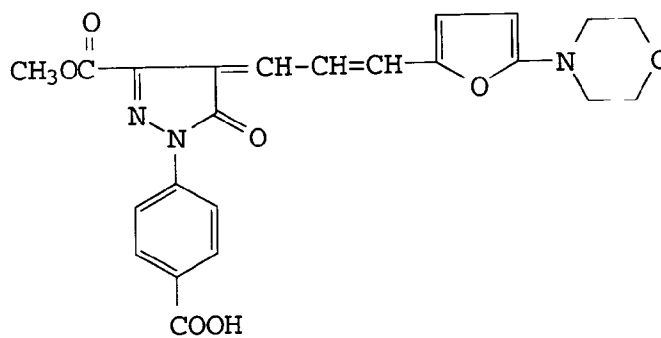
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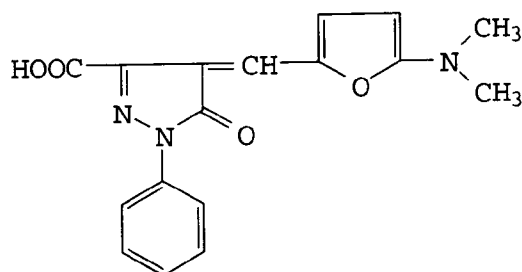
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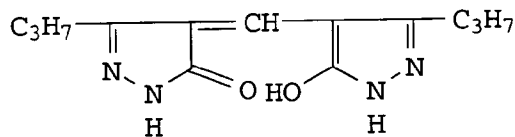
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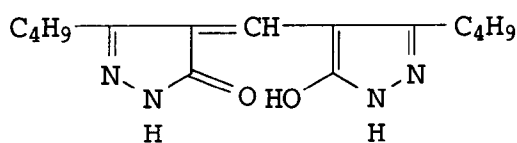
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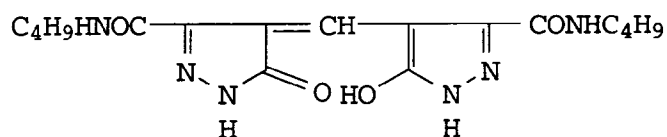
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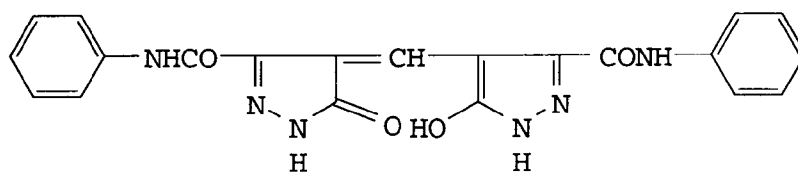
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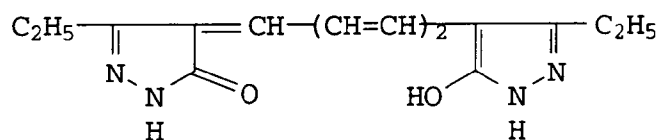
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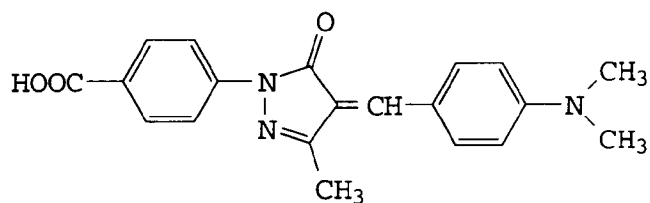
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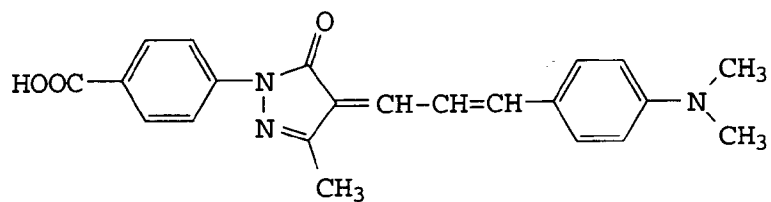
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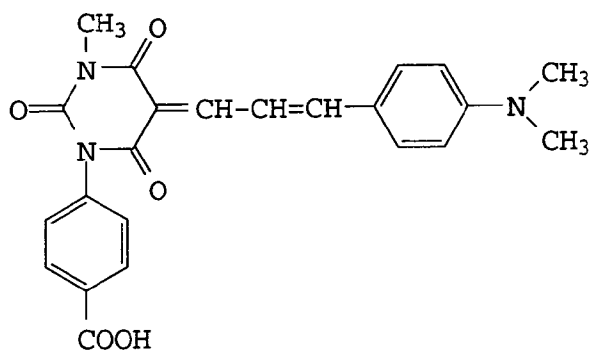
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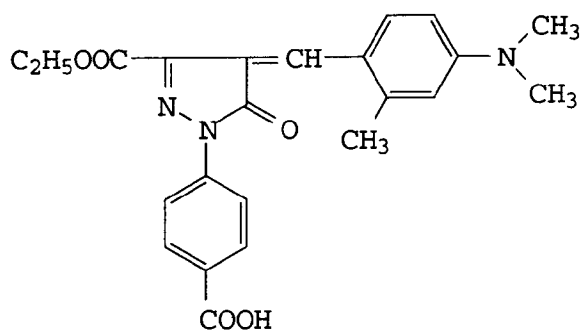
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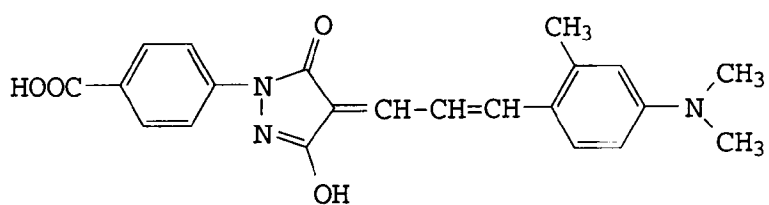
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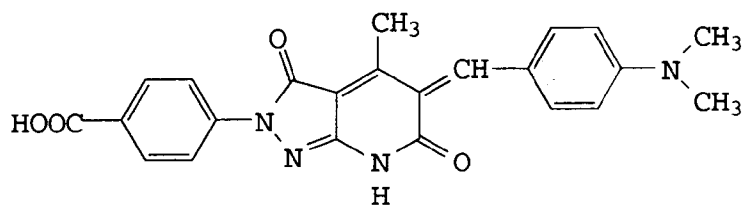
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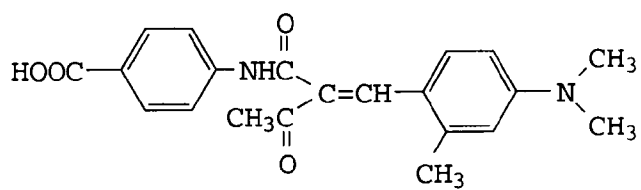
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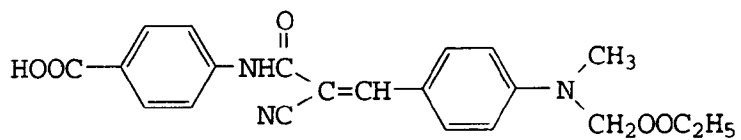
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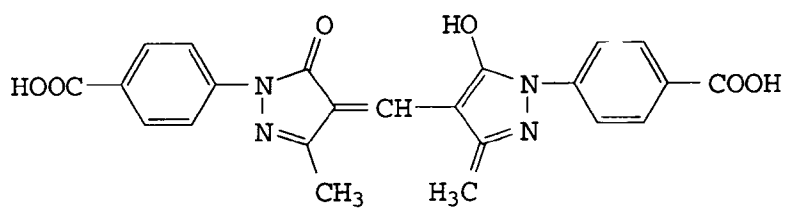
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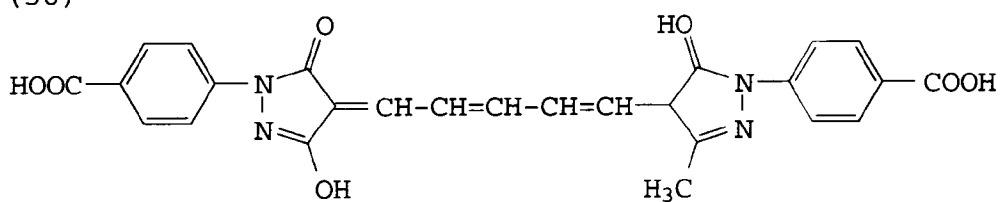
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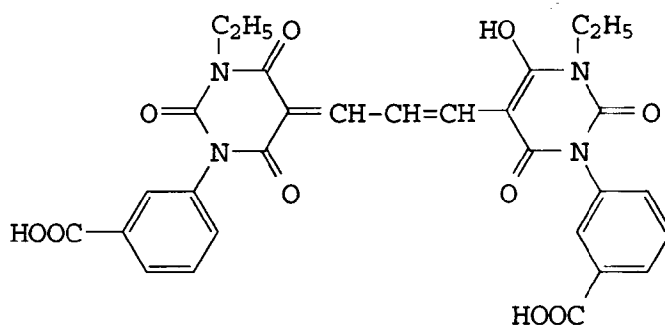
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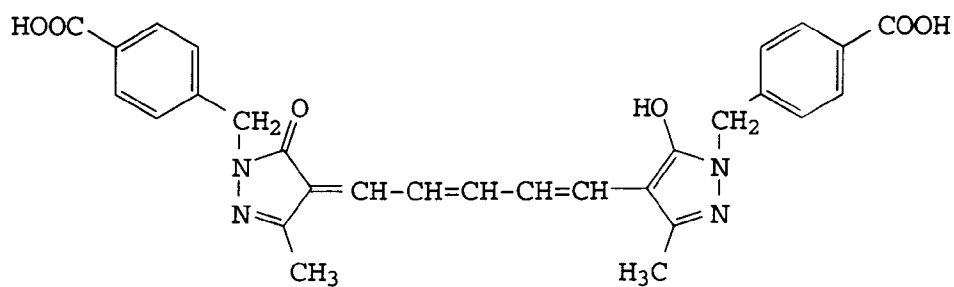
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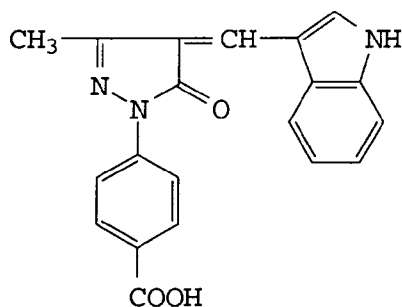
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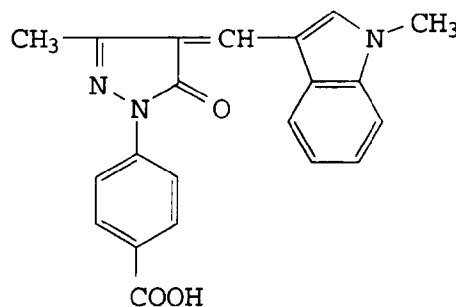
(58)



(59)



(60)



On the dye layer, a silver halide emulsion layer is coated. As a composition of silver halide of the silver halide emulsion which can be used for the present invention include, any silver halide can be used for example, silver bromide, silver bromiodide and silver bromochloriodide. The preferable silver halide composition is a silver bromiodide emulsion containing silver iodide of 5 mol% or less.

The silver halide grain may be any crystal type provided that it is of the constitution of the present invention. For example, a mono-crystal such as cubic, octahedral and tetradecahedral are allowed, and a poly-twinned grain having various forms are allowed.

An emulsion used for the silver halide photographic light-sensitive material of the present invention can be produced by a conventional method. For example, a method described in Research Disclosure (RD) No. 17643 (December, 1978), pp. 22 to 23 "Emulsion Preparation and Types" or a method described in RD No. 18716 (November, 1979), on page 648 can be used for preparation.

The emulsion used for the silver halide photographic light-sensitive material of the present invention can be used by a method described in "The Theory of the Photographic Process" 4th edition written by T.H. James, published by Macmillan Inc. (1979), pp. 38 to 104, a method described in "Photographic Emulsion Chemistry" written by G.F. Duffin, published by Focal Press Inc. (1966), a method described in "Chimie et Physique Photographique" written by P. Glafkides, published by Paul Montel Inc. (1967) or a method described in "Making And Coating Photographic Emulsion" written by V.L. Zelikman, published by Focal Press Inc. (1964) for preparation.

Namely, under a solution condition of an acid method, an ammonia method and a neutral method, a mixing condition such as an ordinary mixing method, a reverse mixing method, a double-jet method or a controlled double-jet method and a grain preparation condition such as a conversion method or a core/shell method or their combination can be used for preparing the emulsion.

The preferable embodiment of the emulsion used for the silver halide photographic light-sensitive material of the present invention includes a mono-dispersed emulsion wherein silver iodide is localized inside the grains. "Mono-dispersed" referred to here is silver halide grains wherein at least 95% by number or by weight of grains is within $\pm 40\%$ and preferably $\pm 30\%$ of the average grain size when an average grain diameter is measured by a conventional method.

Grain distribution of silver halide may be of mono-dispersed emulsion having a narrow distribution or of poly-dispersed emulsion having a wide distribution. The crystal structure of silver halide may be composed of a silver halide composition wherein inside and outside are different or it may be a core/shell type mono-dispersed emulsion having a clear two-layer structure wherein a shell layer of low silver iodide is laminated on a core portion of high silver iodide.

Production method of the above-mentioned mono-dispersed emulsion is conventional. It is described in J. Phot. Sci, 12.242 through 251 (1963), Japanese Patent OPI. Publication Nos. 36890/1973, 16364/1977, 142329/1980 and 49938/1983, British Patent No. 1,413,748 and USP Nos. 3,574,628 and 3,655,394 in detail.

As an emulsion used for the silver halide photographic light-sensitive material of the present invention for obtaining the above-mentioned mono-dispersed emulsion, an emulsion wherein a seed crystal is used and silver ions and halide ions are supplied with this seed crystal as a growing nuclei for growing may be used.

Production method of the above-mentioned core/shell type emulsion is conventional. For example, methods described in J. Phot. Sci, 24.198. (1976), USP. Nos. 2,592,250, 3,505,068, 4,210,450 and 4,444,877 and Japanese Patent OPI. Publication No. 143331/1985 can be referred.

The above-mentioned emulsion may be either of a surface latent image type wherein latent images are formed on the surface of grains, an inner latent image type wherein latent images are formed inside of the grains or a type wherein latent images are formed on the surface and inside of the grains.

To these emulsion, at a step of physical ripening or of preparation of grains, for example, cadmium salt, lead salt, zinc salt, thallium salt, iridium salt or its complex salt, rhodium salt or its complex salt and iron salt or its complex salt

may be added.

In order to remove soluble salts from the emulsion, a noodle washing method and a flocculation precipitation method can be used. The preferable washing methods include a method that uses an aromatic hydrocarbon aldehyde resin containing a sulfo group described in Japanese Patent Publication No. 16086/1960 or a desalting method that uses polymer coagulation agents illustrated G-3 and G-8 described in Japanese Patent OPI. Publication No. 158644/1988.

To the emulsion used for the silver halide photographic light-sensitive material of the present invention, in a physical ripening or before or after a chemical ripening step, various photographic additives may be used. As compounds used in such a step, various compounds described in the above-mentioned (RD) No. 1743, (RD)No. 18716 and (RD) No. 308119 (December, 1989) can be used. Kinds of compounds and places described in the above-mentioned three (RD) Research Disclosures will be described below.

Additive	RD-17643		RD-18716	RD-308119	
	Page	Classification	Page	Page	Classification
Chemical sensitizer	23	III	648 upper right	996	III
Sensitizing dye	23	IV	648-649	996-8	IVA
Desensitizing dye	23	IV		998	IVB
Dye	25-26	VIII	649-650	1003	VIII
Development accelerator	29	XXI	648 upper right		
Anti-foggant, stabilizer	24	IV	649 upper right	1006-7	VI
Brightening agent	24	V		998	V
Hardener	26	X	651 left	1004-5	X
Surfactant	26-27	XI	650 right	1005-6	XI
Plasticizer	27	XII	650 right	1006	XII
Lubricant	27	XII			
Matting agent	28	XVI	650 right	1008-9	XVI
Binder	26	XXII		1003-4	IX
Support	28	XVII		1009	XVII

Hereunder, practical examples of the present invention will be explained.

EXAMPLES

Example 1

(1) The following radiographic intensifying screens respectively having two sheets for composing one set (namely, for a front placement use and for a rear placement use) were prepared.

SRO-250 (commercially available article produced by Konica Corporation)

SRO-500 (commercially available article produced by Konica Corporation)

Radiographic intensifying screen A (a test product A)

Radiographic intensifying screen A (a test product B)

1) Production of the radiographic intensifying screen A

As a coating solution for forming a fluorescent substance sheet, 8 parts by weight of fluorescent substance ($\text{Gd}_2\text{O}_2\text{S}$: Tb) having an average grain size of 4 μm and 1 part by weight of nitrocellulose were mixed by the use of a solvent (a mixture solution of acetone, ethyl acetate and butyl acetate in a weight ratio of 1:1:8) so that a coating solution having viscosity of 30 PS (25°C) was prepared. This fluorescent substance coating solution was coated on a polyethylene terephthalate (a tentative support, the thickness is 180 μm), on which a silicone mold relieving agent is coated, in a manner that a layer thickness becomes 150 μm (layer thickness after compression pressure described later) and dried to form a fluorescent substance sheet. Following this, the fluorescent substance sheet was peeled off from the tentative support.

Separately, a coating solution for a subbing layer was formed as follows: 90 g of a soft acrylic resin and 50 g of nitrocellulose were added to methylethylketone for mixing and dispersing so that a dispersion solution having viscosity of 3 to 6 PS (25°C) was prepared.

A polyethylene terephthalate support having a thickness of 250 μm which has a carbon black light-absorption layer

was placed horizontally on a glass plate. The above-mentioned coating solution for a subbing layer was coated on the support uniformly using a doctor blade. Thereafter, the temperature was raised gradually from 25°C to 100°C for drying the coating layer. Thus, a subbing layer having a layer thickness of 15 µm was formed on the support. On this, the fluorescent substance sheet formed above was placed. By means of a calender roll, the fluorescent substance sheet

was subjected to compression operation at a pressure of 510 Kg/cm² and temperature of 80°C. Separately, 70 g of a fluorine-containing resin (a fluoroolefin and vinyl ether copolymer), 25 g of a cross-linking agent (isocyanate type), 5 g of bisphenol A type epoxy resin and 5 g of alcohol denatured silicone oligomer (a substance having a dimethylpolysiloxane skeleton and having a hydroxide group at the both ends) were added to a mixture solvent of toluene and isopropyl alcohol (the volume ratio is 1:1) for forming a coating solution for forming a protective layer. The above-mentioned coating solution for the protective layer was coated by the use of a doctor blade on the surface of the fluorescent substance sheet provided with compression operation on the support in advance. The coating solution was heated for 30 minutes at 120°C for drying and thermal hardening to form a transparent protective layer having thickness of 3 µm. Thus, radiographic intensifying screen A composed of the support, the subbing layer, the fluorescent substance layer and the transparent protective layer was produced.

2) Production of the radiographic intensifying screen B

Radiographic intensifying screen B composed of a support, a subbing layer, a fluorescent substance layer and a transparent protective layer was prepared, in the same manner as in radiographic intensifying screen A except that the layer thickness of the fluorescent substance sheet (the thickness after compression processing) was 230 µm.

(2) Measurement of characteristics of the radiographic intensifying screens

In the invention characteristics of the intensifying screens are measured according to the following method.

1) Measurement of X-ray absorption amount

An X-ray created from a tungsten target tube operated at 80 KVp by a three phase power supply was transmitted through an aluminum plate with thickness of 3 mm to be reached to a sample radiographic intensifying screen fixed at a position of 200 cm from the tungsten anode of the target tube. Next, the amount of X-ray transmitted through the intensifying screen was measured by the use of an electrolytic dosimeter at a position of 50 cm separating from the fluorescent substance layer of the intensifying screen to obtain an absorption amount of the X-ray. Incidentally, as a standard value, a measurement value was measured in the same manner as above, except that the X-ray was not transmitted through the intensifying screen was used. Table 1 shows the measurement value of X-ray absorption values of each intensifying screen.

2) Measurement of contrast transfer function (CTF)

NEW C one-sided light-sensitive material, produced by Konica Corporation was placed to be in contact with an intensifying screen to be measured, and a chart for measuring MTF (produced by DaiNippon Toryo Co., Ltd., thickness: 0.05 mm, spatial frequency: 0.5 LP/mm to 10 LP/mm) was photographed. The chart was positioned at 1.5 meters at a distance from an X-ray tube. The light-sensitive material was placed in front of the X-ray source, and an intensifying screen was placed at the back of the light-sensitive material. The X-ray tube used was DRX-2903HD produced by Toshiba wherein a tungsten target was used and the focal spot size was 2.0 x 1.0 mm. Through 3 mm of aluminium including an aperture, an X-ray is emitted. Voltage of 80 KVp was applied to three phases by means of a pulse generator to produce an X-ray which passed through 7 cm of water filter having absorption almost equivalent to human body as a radiation source. The light-sensitive material after being exposed was subjected to photographic processing by the use of an automatic processing machine Model FPM-5000 produced by Fuji Film Co., Ltd., developing solution XD-90 and fixing solution, each produced by Konica Corporation at a developing temperature of 35°C and fixing a temperature of 33°C. Thus, a measurement sample was prepared. Incidentally, the exposure amount in X-ray photographing was adjusted in a manner that the average value of the maximum density and the minimum density after the above-mentioned photographic processing is 1.1.

Next, the measurement sample was operated with a micro densitometer. In the instance, for an aperture, a slit having 30 µm for an operation direction and 500 µm for a vertical direction thereof was used and a density profile was measured at a sampling interval of 30 µm. This operation was repeated 10 times and the average value was calculated to obtain a basic density profile for calculating the CTF.

Subsequently, a peak for every frequency of the above-mentioned density profile was detected so that density contrast for each frequency was calculated. Table 1 shows values of the spatial frequency of 1 line/mm and 3 lines/mm.

3) Measurement of sensitivity

NEW C, one sided light-sensitive material subjected to ortho sensitization, produced by Konica Corporation, was subjected to step wedge exposure with width of $\log E = 0.15$ in which the X-ray exposure amount was changed by a distance method, using the same X-ray source as the above CTF measurement. After exposure to light, the light-sensitive material was subjected to photographic processing in the same condition as in the CTF measurement. Thus, a measurement sample was obtained. The density of the measurement sample was measured with visible light so that a characteristic curve was obtained. The sensitivity was represented by an inverse of an X-ray exposure amount necessary to obtain density, $D_{\min} + 1.0$, and expressed by a relative sensitivity when the value of intensifying screen SRO-250 on the behide side (defined later) was defined to be 100. Table 1 shows the results thereof.

Table 1

*	Absorption amount of X-ray	Sensi- tivity	CTF (1 line/mm)	CTF (3 lines/mm)
SRO-250 on the front side	37	102	0.84	0.54
SRO-250 on the back side	36	100	0.85	0.54
SRO-500 on the front side	36	166	0.72	0.32
SRO-500 on the back side	51	235	0.73	0.33
Radiographic intensifying screen A	47	168	0.81	0.45
Radiographic intensifying screen B	63	241	0.80	0.38

* In Table 1,

"SRO-250 on the front side" refers to SRO-250 to be positioned in front of an X-ray radiation source of two screens sandwiching a light-sensitive material.

"SRO-250 on the back side" refers to SRO-250 to be positioned on the side opposite "SRO-250 on the front side" with respect to the light-sensitive material.

"SRO-500 on the front side" refers to SRO-500 to be positioned in front of an X-ray radiation source of two screens sandwiching a light-sensitive material.

"SRO-500 on the back side" refers to SRO-500 to be positioned on the side opposite "SRO-500 on the front side" with respect to the light-sensitive material.

(3) Preparation of a silver halide photographic light-sensitive material

1) Production of silver halide photographic light-sensitive material 1

<Preparation of emulsion>

A silver bromiodide emulsion composed of 1.3 mol% of silver iodide and 98.7 mol% of silver bromide was prepared. In this emulsion, an average grain size was 1.22 μm , an average grain thickness was 0.41 μm and the dispersion of the grain size was 0.23 in terms of variation coefficient (in accordance with a method described in Japanese Patent OPI Publication No. 162244/1985). The resulting emulsion was defined to be (A).

In the same manner, a silver bromiodide emulsion composed of 1.3 mol% of silver iodide and 98.7 mol% of silver bromide was prepared wherein an average grain size is 0.69 μm , an average grain size thickness is 0.24 μm and the dispersion of the grain size is 0.26 in terms of variation coefficient. The resulting emulsion was defined to be emulsion (B).

Further, a silver bromiodide emulsion composed of 1.4 mol% of silver iodide and 98.6 mol% of silver bromide was prepared. The form of this emulsion was octahedral whose grain size dispersion was 0.17 in terms of variation coefficient. The resulting emulsion was defined to be (C).

<Preparation of a sample>

The following sensitizing dyes (X) and (Y) were added at 55°C to (A) in an amount of 400 mg per mol of silver halide, to (B) in an amount of 900 mg per mol of silver halide and to (C) in an amount of 1100 mg per mol of silver halide wherein the weight ratio of (X) and (Y) was 20:1.

Sensitizing dye (X); Anhydride of 5,5'-dichloro-9-ethyl-3,3'-di-(3-sulfopropyl)-oxacarbocyanine-sodium salt

Sensitizing dye (Y); Anhydride of 5,5'-di-(butoxycarbonyl)-1,1'-diethyl-3,3'-di-(4-sulfobutyl)-benzimidazolo-carbocyanine-sodium salt

After 10 minutes, an appropriate amount of chloroauric acid, sodium thiosulfate and ammonium thiocyanate were added for chemical ripening. Forty minutes before the end of ripening, 0.06 μm of silver iodide fine particle emulsion was added thereto in an amount of 6×10^{-4} mol of silver. Thereafter, 4-hydroxy-6-methyl 1,3,3a,7-tetrazaindene was added thereto in an amount of 3×10^{-2} mol per mol of silver halide. The resulting emulsion was dispersed in an aqueous

solution containing 70 g of gelatin.

Following this, emulsions (A), (B) and (C) were mixed at a rate of 10:65:25 in terms of mol ratio of silver halide.

To this emulsion, an additive described in Japanese Patent OPI Publication No. 301744/1990, from the 16th line on page 95 to the 20th line on page 96 was added.

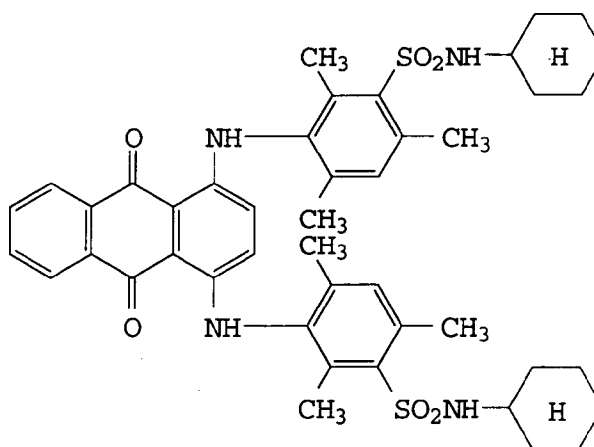
In addition, 1.0 g of the following dye emulsified and dispersed solution was added to make an emulsion coating solution.

Preparation method of dye emulsified and dispersed solution

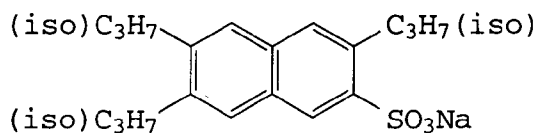
Ten kg of the following dye were dissolved in a solvent composed of 28 liters of tricresyl phosphate and 85 liters of ethyl acetate at 55°C. This is referred to as an oil-based solvent. On the other hand, 10 liter of a 9.3% aqueous gelatin solution containing 1.35 kg of anionic surfactant (AS) is referred to as a water-based solvent.

Next, the oil-based solvent and the water-based solvent were placed in a dispersion tank. While keeping at 40°C, they were dispersed.

(Dye)

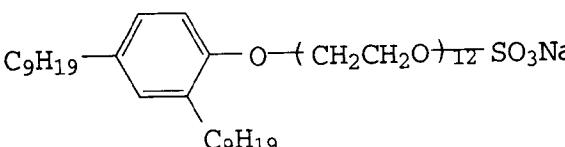
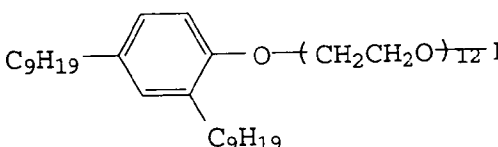
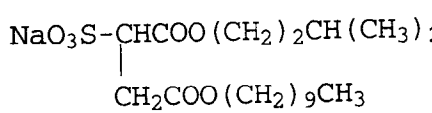
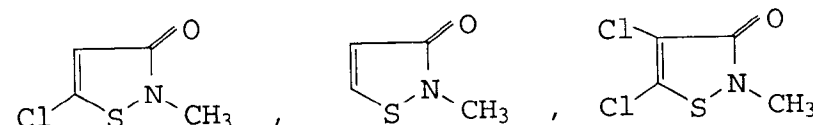


(AS)



Additives used for a protective layer were as follows. The amounts added are represented by those per 1 liter of coating solution.

Coating solution for protective layer

5	Inert gelatin processed with lime	68 g
	Gelatin processed with acid	2 g
10	Polymethylmethacrylate (A matting agent having an area average grain size of 6.0 μm)	1.1 g
15	Silicone dioxide grain (A matting agent having an area average grain size of 3.0 μm)	0.5 g
	A 40% aqueous solution of glyoxal (hardener)	1.5 ml
20	$(\text{CH}_2=\text{CHSO}_2\text{CH}_2)_2\text{O}$ (hardener)	500 mg
	$\text{C}_{11}\text{H}_{23}\text{CONH}(\text{CH}_2\text{CH}_2\text{O})_5\text{H}$	2.0 g
25		20 mg
30		7 mg
35		7 mg
40	$\text{C}_{12}\text{H}_{25}\text{CONH}(\text{CH}_2\text{CH}_2\text{O})_5\text{H}$	62 mg
45	 (50:46:4)	0.9 mg

50 Support

On each surface of a subbed polyethylene terephthalate support having a thickness of 175 μm colored to blue at density of 0.15, a coating solution having the following composition was coated in an amount of a dye as shown below to form a dye layer.

55

Dye (illustrated compound 20)	20 mg/m ²
Gelatin	0.7 g/m ²
Nonylphenoxypolyethylene oxide (the degree of polymerization is 10)	6 mg/m ²
1-morphorinocarbonyl-3-(pyridinio)methanesulfonate	80 mg/m ²
Polymethacrylic acid methyl (A matting agent having an average grain size of 2.5 μm)	2 mg/m ²

On the support as above-mentioned, an emulsion layer and a surface protective layer were coated in a manner that an emulsion coating solution was 2.3 g/m² in terms of silver on one surface, the amount of gelatin was 2.0 g/m² and the amount of gelatin for the protective layer was 0.9 g/m² by means of a simultaneous extrusion coating method at the speed of 90 meters per minute. The resulting layers were dried for 2 minutes and 30 seconds to produce silver halide photographic light-sensitive material 1.

2) Production of silver halide photographic light-sensitive material 2

In the same manner as in the above-mentioned silver halide photographic light-sensitive material 1, silver halide photographic light-sensitive material 2 was produced, except that the coating amount of dye (illustrated compound 20) in the dye layer was changed to 30 mg/m².

3) Production of silver halide photographic light-sensitive material 3

In the same manner as in the above-mentioned silver halide photographic light-sensitive material 1, silver halide photographic light-sensitive material 3 was produced, except that the coating amount of dye (illustrated compound 20) in the dye layer was changed to 70 mg/m².

4) Production of silver halide photographic light-sensitive material 4

In the same manner as in the above-mentioned silver halide photographic light-sensitive material 1, silver halide photographic light-sensitive material 4 was produced, except that the coating amount of dye (illustrated compound 20) in the dye layer was changed to 85 mg/m².

5) Production of silver halide photographic light-sensitive material 5

<Preparation of emulsion>

A silver bromiodide emulsion composed of 1.5 mol% of silver iodide and 98.5 mol% of silver bromide was prepared. This emulsion was octahedral whose average grain size is 0.41 μm and the dispersion property of grain size is 0.16 in terms of variation coefficient. The resulting emulsion was defined to be (E).

Concurrently with this, octahedral silver bromiodide emulsions respectively composed of 1.5 mol% of silver iodide and 98.5 mol% of silver bromide whose average grain sizes were 0.57 μm and 1.1 μm were prepared. They were respectively defined to be emulsions (F) and (G).

The resulting emulsions (E), (F) and (G) were subjected to the optimal sensitization in the same manner as that in production of silver halide light-sensitive material 1.

Following this, emulsions (E), (F) and (G) were mixed in a ratio of 3:6:1 to make a coating emulsion. Afterward, in the same manner as in the foregoing production method of silver halide photographic light-sensitive material 2, silver halide photographic light-sensitive material 5 was produced.

6) Production of silver halide photographic light-sensitive material 6

<Preparation of emulsion>

A silver bromiodide emulsion composed of 1.3 mol% of silver iodide and 98.7 mol% of silver bromide was prepared. This emulsion has an average grain size of 1.50 μm , average grain size thickness of 0.49 μm and dispersion property of particle size of 0.28 in terms of variation coefficient. The resulting emulsion was defined to be (H).

In the same manner, an emulsion whose average grain size is 0.79, an average grain size thickness is 0.26 and the dispersion property of grain size was 0.24 in terms of variation coefficient was obtained. The resulting emulsion was defined to be (I).

In addition, an emulsion whose average grain size is 0.56, an average grain size thickness is 0.23 and the dispersion property of grain size was 0.20 in terms of variation coefficient was obtained. The resulting emulsion was defined to be (J).

The resulting emulsions (H), (I) and (J) were subjected to the optimal sensitization in the same manner as in silver halide light-sensitive material 1.

Following this, emulsions (H), (I) and (J) were mixed in mol ratio of 8:67:25 to prepare a coating emulsion. In the same manner as in the above-mentioned silver halide photographic light-sensitive material 3 silver halide photographic light-sensitive material 6 was produced, except that the coating emulsion was coated by 2.5 g/m^2 in terms of silver on one side.

7) Production of silver halide photographic light-sensitive material 7

<Preparation of emulsion>

A silver bromiodide emulsion composed of 1.3 mol% of silver iodide and 98.7 mol% of silver bromide was prepared. This emulsion has an average grain size of 1.61 μm , average grain size thickness of 0.52 and dispersion property of 0.32 in terms of variation coefficient. The resulting emulsion was defined to be (K).

In the same manner, an emulsion whose average grain size was 0.83 μm , an average grain size thickness was 0.27 μm and the dispersion property of grain size was 0.25 in terms of variation coefficient was obtained. The resulting emulsion was defined to be (L).

In addition, an emulsion whose average grain size was 0.60 μm , an average grain size thickness was 0.24 μm and the dispersion property of grain size was 0.25 in terms of variation coefficient was obtained. The resulting emulsion was defined to be (M).

The resulting emulsions (K), (L) and (M) were subjected to the most appropriate sensitization in the same manner as that in production of silver halide light-sensitive material 1.

Following this, emulsions (K), (L) and (M) were mixed in mol ratio of 8:67:25 to prepare a coating emulsion. In the same manner as in the above-mentioned silver halide photographic light-sensitive material 6, silver halide photographic light-sensitive material 7 was produced.

8) Production of silver halide photographic light-sensitive material 8

<Preparation of emulsion>

A silver bromiodide emulsion composed of 1.3 mol% of silver iodide and 98.7 mol% of silver bromide was prepared. This emulsion has an average grain size of 0.46 μm , average grain size thickness of 0.22 μm and dispersion property of grain size of 0.15 in terms of variation coefficient. The resulting emulsion was defined to be (N).

a silver bromiodide emulsion composed of 1.5 mol% of silver iodide and 98.5 mol% of silver bromide was coated. This emulsion was octahedral whose average grain size was 0.64 μm and the dispersion property of grain size was 0.16 in terms of variation coefficient. The resulting emulsion was defined to be (O).

In the same manner, an octahedral silver bromiodide emulsion composed of 1.5 mol% of silver iodide and 98.5 mol% of silver bromide and having an average grain size of 1.25 μm was defined to be (P).

The resulting emulsions (N), (O) and (P) were subjected to the optimal sensitization in the same manner as that in production of silver halide photographic light-sensitive material 1.

Following this, a material wherein emulsions (N), (O) and (P) were mixed by 1:6:3 in terms of mol ratio of silver halide was defined to be a coating emulsion. Afterward, in the same manner as in production of silver halide photographic light-sensitive material 3, silver halide photographic light-sensitive material 8 was produced.

9) Production of silver halide photographic light-sensitive material 9

In the same manner as in the production method of the above-mentioned silver halide photographic light-sensitive material 5, silver halide photographic light-sensitive material 9 was produced, except that the dye in the subbing layer on the support was replaced with illustrated compound 1 and its coating amount was changed to 20 mg/m² on one surface.

10) Production of silver halide photographic light-sensitive material 10

In the same manner as in the production method of the above-mentioned silver halide photographic light-sensitive material 1, silver halide photographic light-sensitive material 10 was produced, except that the coating amount of dye (illustrated compound 1) on a subbing layer on a support was changed to 10 mg/m².

11) Production of silver halide photographic light-sensitive material 11

<Preparation of emulsion>

A silver bromoiodide emulsion composed of 1.3 mol% of silver iodide and 98.7 mol% of silver bromide was prepared. This emulsion has an average grain size of 0.72 μm , average grain size thickness of 0.23 and dispersion property of grain size of 0.15 in terms of variation coefficient. The resulting emulsion was defined to be (Q).

In the same manner, an emulsion whose average grain size was 0.53 μm , an average grain size thickness was 0.21 μm and the dispersion property of grain size was 0.18 in terms of variation coefficient was obtained. The resulting emulsion was defined to be (R).

The resulting emulsions (Q) and (R) were subjected to the optimal sensitization in the same manner as that in production of silver halide photographic light-sensitive material 1.

Following this, emulsions (Q) and (R) were mixed at the rate of 85:15 in terms of mol ratio of silver halide to prepare a coating solution. This emulsion was coated by 2.7 g/m² in conversion to silver per one surface. In the same production method as that in production of the above-mentioned silver halide photographic light-sensitive material 1, silver halide photographic light-sensitive material 11 was produced, except the coated amount of dye (illustrated compound 1) on the subbing layer of the support was changed to be 85 mg/m².

(4) Measurement of characteristics of silver halide photographic light-sensitive material

1) Measurement of sensitivity

By the use of a 102 interference filter produced by Nippon Shinkuu Kohgaku Co., Ltd. (546 nm, light whose half width is 10 nm) and a tungsten light source whose color temperature was 2856K as an irradiation light, a light-sensitive material was exposed through a neutral step wedge for 1/12.5 seconds. After exposure, the light-sensitive material was developed at 35 °C for 25 seconds (the total processing time was 90 seconds) by the use of automatic processing machine FPM-5000 (produced by Fuji Film Co., Ltd.) and a developing solution having the following composition. After the light-sensitive layer on the opposite side of the exposure surface was peeled off, the density was measured for obtaining characteristic curve. From the characteristic curve, an exposure amount necessary to obtain density of the minimum density (Dmin) plus 0.5 was calculated and defined to be sensitivity. The sensitivity is shown in Table 2 in terms of lux•second. Incidentally, in calculating exposure amount, illuminance emitted from the tungsten light source and transmitted through the filter was measured by the use of illuminator IM-3 (produced by TOPCON Co., Ltd.).

Composition of a developing solution

Pottasium hydroxide	21 g
Pottasium sulfite	63 g
Boric acid	10 g
Hydroquinone	26 g
Triethylene glycol	16 g
5-methyl benztriazole	0.06 g

Continuation of the Table on the next page

(continued)

1-phenyl-5-mercapto tetrazole	0.01 g
Glacial acetic acid	12 g
1-phenyl-3-pyrazolidone	1.2 g
Glutaric aldehyde	5 g
KBr	4 g

Water was added to make 1 liter in total, and pH was regulated to 10.0.

2) Measurement of crossover

The silver halide photographic light-sensitive material was sandwiched with radiographic intensifying screen SRD-250 (produced by Konica Corporation) and a black paper. From the black paper side, X-ray was irradiated. As the X-ray source, the same source as that used in the evaluation of intensifying screen was used. The X-ray was irradiated while the irradiation amount of the X-ray was changed by means of a distance method. After irradiating, the light-sensitive material was subjected to photographic processing in the same manner as in the measurement of the above-mentioned sensitivity. This processed light-sensitive material was divided into two portions and a light-sensitive layer on one side was peeled off. The density of the light-sensitive layer which was in contact with the intensifying screen was higher than that of the light-sensitive layer on the opposite side. For each light-sensitive layer, a characteristic curve was obtained. The average value $\overline{\Delta \log E}$ of sensitivity difference of ($\Delta \log E$) between each sensitivity in each straight line portion was calculated. From this average value, crossover value was calculated by means of the following equation.

$$\text{Crossover (\%)} = 100 / \text{antilog}(\overline{\Delta \log E}) + 1$$

Table 2 shows the results thereof.

Table 2

	Sensitivity on one surface (Dmin+0.5) [lux*second]	Crossover (%)
Silver halide photographic light-sensitive material 1	0.0094	17.7
Silver halide photographic light-sensitive material 2	0.0094	14.2
Silver halide photographic light-sensitive material 3	0.0094	5.9
Silver halide photographic light-sensitive material 4	0.0094	4.1
Silver halide photographic light-sensitive material 5	0.0120	14.3
Silver halide photographic light-sensitive material 6	0.0063	14.0
Silver halide photographic light-sensitive material 7	0.0056	14.2
Silver halide photographic light-sensitive material 8	0.0104	14.2
Silver halide photographic light-sensitive material 9	0.0120	18.3
Silver halide photographic light-sensitive material 10	0.0094	23.9
Silver halide photographic light-sensitive material 11	0.0084	1.9

(5) Evaluation of characteristics of a composite of silver halide photographic light-sensitive material and radiographic intensifying screen

1) Measurement of sensitivity and γ

The composite was subjected to exposure and photographic processing in the same manner as in the above-mentioned sensitivity measurement method of an intensifying screen, except that a light-sensitive material to be evaluated was sandwiched with 2 sheets of intensifying screens to be evaluated. The sensitivity was represented by a relative value of an inverse of an X-ray exposure amount necessary to obtain the minimum density (D_{min}) + 1.0, with the proviso that the sensitivity of composite, SRO-250 silver halide photographic light-sensitive material was a standard value (100). The γ value was represented by an average γ value between density 1.0 and 2.0.

2) Measurement of MTF

The light-sensitive material to be evaluated was sandwiched with two intensifying screens to be evaluated in a conventional manner, and then, the above-mentioned rectangular chart for measuring the MTF was photographed. The chart was placed 2 meters from the above-mentioned X-ray tube, and on the front side of the chart in terms of the X-ray source, a light-sensitive material was placed, and the intensifying screen was placed at the back side thereof. The light-sensitive material after being exposed was subjected to photographic processing in the same manner as above by the use of the above-mentioned roller conveyance type automatic processing machine (FPM-5000) so that a measurement sample was prepared. Incidentally, an amount of exposure in radiographing was also adjusted in the same manner as above. Next, the measurement sample was manipulated by means of a microdensitometer so that density profile was measured. This operation was repeated 20 times so that an average value was calculated. This was defined to be a basic density profile for calculating the CTF. Following this, a peak of rectangular wave for each frequency was detected so that density contrast for each frequency was calculated. Next, by the use of a characteristics curve calculated separately, the above-mentioned density contrast was converted to a rectangular contrast of an effective exposure amount. In order to deduce the MTF, model MTF (ν) was assumed:

$$MTF(\nu) = b(1 + (a\nu)^2)^{-1}$$

(a and u are independently parameters.) In the same procedure of the deduction of Contman's equation, the rectangular contrast of the effective exposure amount was represented by MTF(ν) and its high frequency component MTF(3), MTF(5), -----MTF(10). The above-mentioned parameter was determined to meet the experiment value. The procedure of the modulation of the equation is described in detail on page 171 of "Radiographic Image Information Technology (I)" written by Uchida et al. (published by Tsuushou Sangyou Kenkyuusha in 1981). By putting such a value in the above-mentioned equation, MTF(ν) was calculated.

3) Visual evaluation

Chest phantom produced by Kyoto Kagaku and a three phase and 12 pulse 110Kvp X-ray source having a focal spot size of 2.0 mm x 1.0 mm (equipped with a filter equivalent to a 3 mm thick aluminium) were used. The phantom was placed at a distance of 150 cm, a scattering-cutting grid having a grid ratio of 10:1 was placed at the back thereof, and, at the back thereof, a composite of light-sensitive material and the intensifying screen was placed for radiographing. Photographic processing was conducted at 35°C for 90 seconds (the developing time was 25 seconds) by the use of automatic processing machine FPM-5000, developing solution XD-90 and fixer XF. X-ray exposure was adjusted by changing exposure time to obtain a density of 1.6 at one specified point in a lung image. Finished chest phantom photographs were observed on a viewing box for sharpness. Mainly, the degree of easiness for observing the shadow of blood vessel in a lung was evaluated. Highest degree was defined to be A, higher degree was defined to be B, standard degree was defined to be C, lower degree capable of being marginally diagnosed was defined to be D and lowest degree unable to be diagnosed was defined to be E.

Graininess was visually checked concurrently. The extremely excellent was defined to be A, the excellent was defined to be B, graininess capable of being diagnosed was defined to be C and the poor was defined to be D.

Table 3

No.	Light-sensitive material-intensifying screen (front/rear)	Sensitivity of the light-sensitive material (Lux•second)	Cross-over (%)	Absorption amount of X-ray in an intensifying screen (%) (for front/for rear)	
1	Light-sensitive material-2 (screen A/screen B)	0.0094	14.2	47/63	Inv.
2	Light-sensitive material-3 (screen A/screen B)	0.0094	5.9	47/63	Inv.
3	Light-sensitive material-6 (screen A/screen B)	0.0063	14.2	47/63	Inv.
4	Light-sensitive material-8 (screen A/screen B)	0.0104	14.0	47/63	Inv.
5	Light-sensitive material-2 (screen A/screen B)	0.0094	14.2	47/63	Inv.
6	Light-sensitive material-2 (screen A/screen B)	0.0094	14.2	47/63	Inv.
7	Light-sensitive material-1 (screen A/screen B)	0.0094	17.7	47/63	Comp.
8	Light-sensitive material-4 (screen A/screen B)	0.0094	4.1	47/63	Comp.
9	Light-sensitive material-5 (screen A/screen B)	0.0120	14.2	47/63	Comp.
10	Light-sensitive material-7 (screen A/screen B)	0.0056	14.0	47/63	Comp.
11	Light-sensitive material-2-SRO-500	0.0094	14.2	36/51	Comp.
12	Light-sensitive material-3-SRO-500	0.0094	5.9	36/51	Comp.
13	Light-sensitive material-2-SRO-250	0.0094	14.0	37/36	Comp.
14	Light-sensitive material-9-SRO-250	0.0120	18.3	37/36	Comp.
15	Light-sensitive material-10-SRO-500	0.0094	23.9	36/51	Comp.
16	Light-sensitive material-10-SRO-250	0.0094	23.9	37/36	Comp.
17	Light-sensitive material-10 (screen A/screen B)	0.0094	23.9	47/63	Comp.
18	Light-sensitive material-11-SRO-250	0.0084	1.9	37/36	Comp.
19	Light-sensitive material-11-SRO-500	0.0084	1.9	36/51	Comp.
20	Light-sensitive material-11 (screen A/screen B)	0.0084	1.9	47/63	Comp.

Table 4

No.	Sensitivity (Dmin+1.0)	γ (1.0-2.0)	MTF		Visual evaluation		
			1 LP/mm	3 LP/mm	Sharpness	Graininess	
1	249	3.57	0.80	0.40	B	A	Inv.
2	231	3.57	0.92	0.42	A	B	Inv.
3	371	3.45	0.80	0.40	B	B	Inv.
4	225	3.60	0.81	0.40	A	A	Inv.
5	202	3.57	0.93	0.44	A	A	Inv.
6	286	3.57	0.79	0.40	B	A	Inv.
7	256	3.57	0.77	0.35	C	A	Comp.
8	226	3.57	0.82	0.42	A	C	Comp.
9	158	3.47	0.80	0.42	B	A	Comp.
10	417	3.40	0.79	0.35	B	D	Comp.
11	244	3.57	0.74	0.32	D	A	Comp.
12	227	3.57	0.76	0.33	C	B	Comp.
13	123	3.57	0.83	0.42	A	C	Comp.
14	100	3.47	0.82	0.41	A	B	Comp.
15	255	3.57	0.67	0.30	D	A	Comp.
16	128	3.57	0.79	0.39	B	B	Comp.
17	259	3.57	0.75	0.33	C	A	Comp.
18	123	3.95	0.85	0.45	A	D	Comp.
19	244	3.95	0.80	0.35	B	C	Comp.
20	249	3.95	0.83	0.43	A	C	Comp.

From the above-mentioned Tables, it can be understood that the composite of the silver halide photographic light-sensitive material and the radiographic intensifying screen of the invention has high sensitivity, is reduced in an X-ray dose amount, high and gives an X-ray image having sharpness and excellent graininess.

Namely, in the case of Nos. 14 and 16, though balance between sharpness and graininess is favorable, sensitivity is low. When cross-over is 15% or higher as in No. 7, sharpness becomes degraded. When cross-over is 5% or lower as in No. 8, graininess is degraded. When sensitivity is too high as in No. 10, graininess is extremely degraded. No. 9 provides poor sharpness regardless of its sensitivity and graininess compared to No. 5 of the present invention. In addition, when compared to No. 1, No. 9 provides poor sensitivity regardless of graininess and sharpness. When comparing the present invention to Nos. 14 and 16, it can be understood that sensitivity can be enhanced while maintaining sharpness and graininess.

In the present invention, by setting the cross-over of the light-sensitive material within 5% to 15%, an image excellent in sharpness and graininess can be provided. When the cross-over of the light-sensitive material is 15% or more, sharpness becomes poor as in No. 7. When the cross-over is 5% or less, graininess cannot be maintained as in No. 8.

In the present invention, it is possible to obtain high sensitivity without deteriorating the graininess in a light sensitive material with sensitivity that an exposure necessary to give the minimum density plus 0.5 is 0.0060 to 0.0110 lux·second. The exposure less than 0.0060 gives markedly lowered graininess.

Claims

1. A composite for radiography essentially consisting of a silver halide photographic light-sensitive material and an intensifying screen positioned on each side of the material, the material comprising a support and a silver halide photographic light-sensitive layer provided on each side of the support, wherein one of the screens has an absorption

of 45% or more of a 80kVp X-ray energy, a contrast transfer function (CTF) of 0.78 or more at a space frequency of 1 line/mm and a contrast transfer function (CTF) of 0.35 or more at a space frequency of 3 line/mm, cross-over is 5 to 15%, and the silver halide photographic light-sensitive layer on the exposed side has a sensitivity that, when the material is exposed to a monochromatic light having the same wavelength as a main emission peak wavelength of the screens and having a half band width of 15 ± 5 nm, and developed with the exposed material at 35°C for 25 seconds with the following developer, an exposure necessary to give a density of the minimum density + 0.5 is 0.0060 to 0.0110 lux-second,

Developer

Potassium hydroxide	21 g
Potassium sulfite	63 g
Boric acid	10 g
Hydroquinone	26 g
Triethylene glycol	16 g
5-methylbenzotriazole	0.06 g
1-phenyl-5-mercaptotetrazole	0.01 g
Glacial acetic acid	12 g
1-phenyl-3-pyrazolidone	1.2 g
Glutaraldehyde	5.0 g
KBr	4.0 g

Water added to 1 liter, and pH adjusted to 10.0.

2. The composite of claim 1, wherein the intensifying screen comprises a binder and a substance selected from the group consisting of a terbium-activated rare earth oxysulfide, a terbium-activated rare earth oxyhalide and a thulium-activated rare earth oxyhalide.
3. The composite of claim 2, wherein said substance is a terbium-activated gadolinium oxysulfide.
4. The composite of claim 2, wherein the weight ratio of said binder to said substance is from 1:1 to 1:100.
5. The composite of claim 2, wherein the weight ratio of said binder to said substance is 1:8 to 1:40.
6. The composite of claim 1, wherein a hydrophilic dye layer containing a dye is provided between the support and the silver halide photographic light-sensitive layer, said hydrophilic dye layer being decolorized by said developer.
7. The composite of claim 6, wherein said hydrophilic dye layer contains an anionic dye.
8. The composite of claim 6, wherein said hydrophilic dye layer on one side of the support contains a dye in an amount of 25 to 80mg per m².
9. The composite of claim 1, wherein said silver halide photographic light-sensitive layer provided on each side of the support comprises silver iodobromide grains.



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 95 30 4394

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP-A-0 577 027 (FUJI PHOTO FILM CO.) 5 January 1994 * page 2, line 5 - page 2, line 9 * * page 4, line 7 - page 5, line 58 * * page 6, line 19 - page 6, line 58 * * page 9, line 48 - page 9, line 50 * * page 11, line 1 - page 12, line 31 * -----	1-9	G03C5/17
			TECHNICAL FIELDS SEARCHED (Int.Cl.6) G03C
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 21 August 1995	Examiner Markowski, V
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document			

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