

Mechanism of the Interimage-Effect in Color Reversal System and Its Application to Improve Color Reproduction

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Introduction

Interimage-effect is a development effect which is generated by the mutual development inhibition among emulsion layers with different color sensitivities, and one of the important factors to influence the color reproduc-tion of color films together with spectral sensitivity and spectral characteristics of dyes.

By taking advantage of interimage-effect, one can prevent the degradation of color quality due to the unwanted absorption of dyes or spectral mixing and improve the color reproduction. In case of color reversal films, an orig-inal photographic image is directly used for appreciation, and the masking technique by colored couplers which is generally used to compensate for the unwanted absorption in case of color negative films, may not be utilized. Thus, the use of interimage-effect is a particularly important means to improve the color reproduction of color reversal films.

In case of color negative films, DIR (Development-Inhibitor-Releasing) couplers are generally used to generate the interimage-effect. In such case, during the color development of multi-layer color films, the development inhibitor is released from the emulsion layer where the DIR coupler is included, and it diffuses to other emulsion layers to inhibit development of silver halide grains within those layers, which results in the interimage-effect.

On the other hand, in case of color reversal films, during the first development (black and white development) of color reversal processing, iodide ions released by development of silver halide grains in a certain emulsion layer play the part of an inhibitor, and diffuse to other emulsion layers to inhibit development of silver halide grains within those layers, which generates the interimage-effect.

As for the mechanism of the interimage-effect of color reversal films, there is a paper by Groet[1] , but after this, no detailed paper including the new findings has been published. Furthermore, there is almost none that describes visually and understandably the examples of improving the color reproduction of color reversal films by use of the interimage-effect.

Thus, the purposes of the present research publication are, (1) reviewing the up-to-date information about the mechanism of the interimage-effect in color reversal system, (2) showing visually and understandably the relation between the interimage-effect and the color reproduction by use of the computer-simulation images, and (3) presenting an actual example of color reversal film design where interimage-effect is utilized to improve the color reproduction.

Experimental

Experiments to clarify the mechanism of interimage-effect of color reversal system were performed by use of model multi-layer films besides actual multi-layer color reversal films. The model multi-layer film was prepared by coating on a base, a red sensitive emulsion layer which forms a cyan dye image as a causing layer of the interimage-effect, a green sensitive layer which forms a magenta dye image as a receiving layer of the interimage-effect, and also a protective layer on these emulsion layers. The sensitometric method proposed by Hanson and Horton[3] was applied to investigate the interimage-effect of these samples. Thus a comparison was made between the sensitometric data for the case where the film was singly exposed to light through one of a red, green or blue filter respectively and those for the case where it was exposed to white light. The samples were developed by the conventional color reversal processing, E-6 processing, and D-logE curves were obtained by measuring the cyan, magenta and yellow dye image densities.

The interimage effect was also measured by another method besides the one above. Namely, after the film was singly exposed wedgewisely to light through one of a red, green or blue filter, and then it was singly exposed uniformly to light through an another filter. The exposed films were developed by the color reversal processing, and the cyan, magenta and yellow dye image densities thus obtained were measured to get D-logE curves.

On the other hand, in order to apply the interimage-effect for the color reproduction improvement technique to the actual color reversal film design, experiments were performed by a computer to simulate visually the relation between the gradation, interimage-effect and color reproduction of color reversal films.

Results and Discussion

Mechanism of the Interimage-Effect of Color Reversal System

In order to clarify the mechanism of the interimage-effect, samples with varying factors of photographic materials were prepared to measure the interimage-effect mentioned above, and the following results were obtained in regard to the mechanism of the interimage-effect.

(1) The interimage-effect is generated in the case where samples are processed in the first developer (black and white development) which includes silver halide solvents such as potassium thiocyanate or sodium sulfite.

(2) The interimage-effect is generated in the case where the silver halide emulsion of the causing layer includes silver iodide.

The results (1) and (2) above support the mechanism of the interimage-effect proposed by Groet[1] that the interimage-effect of color reversal films is generated when the black and white developer includes a silver halide solvent, and also if the silver halide emulsion in the causing layer includes silver iodide, iodide ions are released to diffuse to the receiving layer and inhibit the solution physical development of the emulsion grains in this layer to cause the interimage-effect.

(3) The interimage-effect of color reversal system is increased by adding a fogged emulsion as described in Groet patent[2], to the receiving layer.

(4) Since the activity of solution physical development of the silver-halide emulsion depends on the solubility of silver-halide grains, for example, if silver-halide grains in the receiving layer are the smaller in the size, the more is the interimage-effect.

(5) The interimage-effect of color reversal system is enhanced by use of the development inhibitors, for examples, as described in Sniadoch[4] and Deguchi[5,6] patents.

(6) The interimage-effect of color reversal system is enhanced imagewisely according to the amount of the developed silver by the use of DIR (Development-Inhibitor-Releasing)-HQ (Hydroquinone)[7,8] .

The mechanism of enhancing the interimage-effect by the DIR-HQ is shown in Figure 1.

The exposed silver halide grains are reduced by the black and white developer to yield developed silver, and at the same time, the oxidized products of the developer are formed. Then the oxidized products of the developer oxidize DIR-HQ to release the development inhibitors. These development inhibitors diffuse to inhibit the development of undeveloped silver halide grains, which results in enhancing the inter-image-effect.

Application of the Interimage-Effect to the Improvement of the Color Reproduction of Color Reversal Films

From the experimental results on the computer to show visually the relation of the gradation, interimage-effect and color reproduction of color reversal films as the simulated images, there has been shown a possibility that a color reversal film characteristic of color reproduction may be materialized by controlling the gradation and the interimage-effect properly. As actual application examples of color reversal film products, Table 1 shows the line-up of color reversal films, Fujichrome, with ISO speed from 50 to 100, and their characteristics of color reproduction.

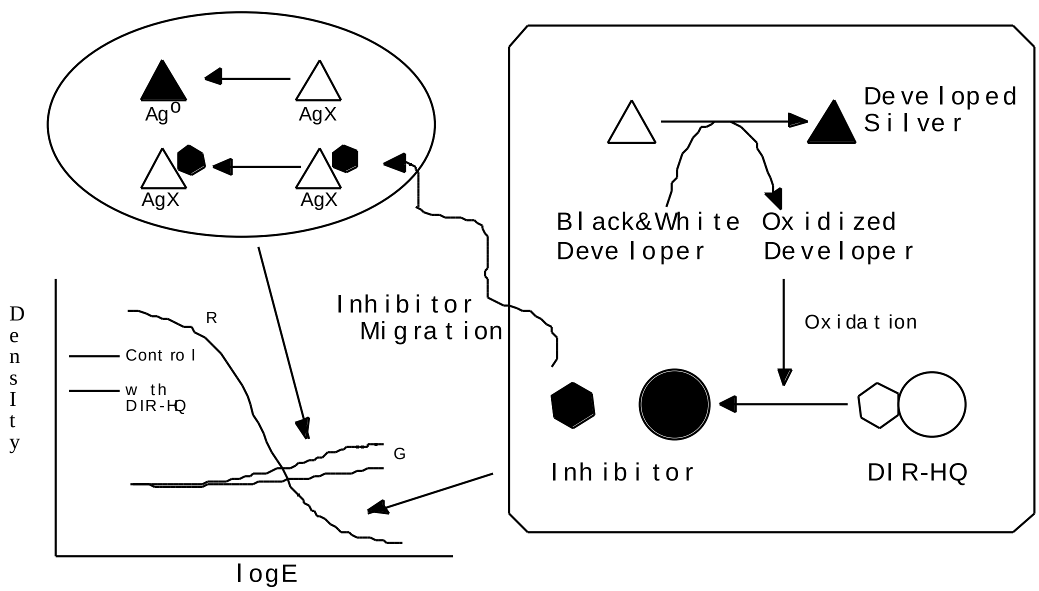

Figure 1 The mechanism of enhancing the interimage-effect by the DIR-HQ

Table 1. Line-up of Fujichrome films and their characteristics

Film Name	Characteristics of Color Reproduction
Velvia 50	Ultra-high chroma and deep color reproduction.
PROVIA100	High chroma and general-purpose color reproduction.
ASTIA 100	High chroma and faithful color reproduction, and smooth and beautiful reproduction of skin color.

The films shown in Table 1 have individual characteristics of color reproduction, and all features of high croma. To all of these films DIR-HQ is introduced, and the increasing action of the interimage-effect by DIR-HQ as described above is one of the important factors in realizing the color reproduction with high chroma. Also, by controlling the gradation and interimage-effect properly for each film, the characteristics of the color reproduction shown in Table 1 have been attained. As an example illustrating the relation between the gradation and the interimage-effect, Figure 2 shows the D-log curves of red sensitive emulsion layers of ASTIA 100 and PROVIA 100 by exposing them to white light and light through a red filter. Figure 2 indicates that when exposed to white light, the highlight gradation of ASTIA 100 is softer than that of PROVIA 100, but that when exposed to light through a red filter, there is almost no difference in the gradation between PROVIA 100 and ASTIA 100. This shows that the interimage-effect of the red sensitive emulsion layer of ASTIA 100 is great on the highlight part, and that ASTIA 100 has not only a rich tone reproduction with the soft highlight gradation, but also maintains a high chroma because of the great interimage-effect on the highlight part.

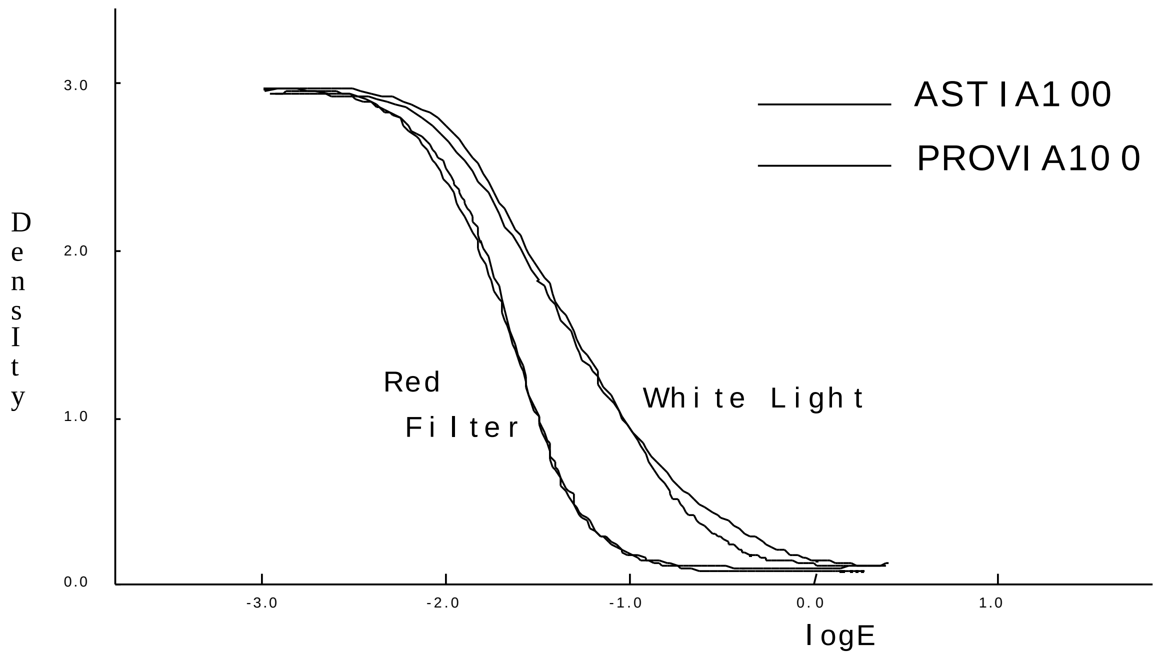

Figure 2 D-logE curves of red sensitive emulsion layers of ASTIA 100 and PROVIA 100 (white-light exposure and exposure to light through a red filter)

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