Image Stability and Performance of a New Silver Halide Color Paper for Digital Printers

CRYSTAL ARCHIVE PAPER TYPE ONE

Shin Soejima, Hiroyuki Yoneyama, and Naoto Ohshima
Ashigara Research Laboratories, Fuji Photo Film Co., Ltd.
Minamiashigara-shi, Kanagawa, Japan

Abstract

FUJICOLOR CRYSTAL ARCHIVE PAPER TYPE ONE is a silver halide color paper designed for digital printers, and is capable of yielding high-image-quality digital prints, especially when it is used with the Digital Minilab Frontier. This color paper allows the attainments of enhanced suitability to high-intensity laser exposure, excellent image stability, brilliant whiteness, and consistent processing result. These features were brought about by the following technologies.

(1) APC (Advanced Photoelectron Controlling) Technology

This technology is to control the behavior of photoelectrons created by high-intensity laser exposure in order to provide high-image-quality digital prints without deterioration of latent image stability by enhancing the concentration of latent image formation.

(2) HDS (Hybrid Dye-image Stability) Technology

This technology enhances the stability of the anti-fading agent to produce unparalleled image permanence.

(3) WE (Whiteness Enhancing) Technology and RR (Resistance to Radiation) Technology

The development of WE technology brings about brilliant whites by retarding the formation of residual dyes during processing. This technology also provides brilliant whites, which do not change among batches by suppressing fog formation due to environmental radiation.

(4) PS (Process Stabilizing) Technology

This technology depends on new chemical sensitization technology, which makes it possible to achieve the required level of sensitivity with smaller silver halide grains than before, and provides more consistent results with faster rate of development than before even when exhausted solutions are used.

Introduction

It is expected that the total number of shots of photography increases and the total demand for color prints as their output also increases with enhanced spread of digital cameras. Silver halide color paper has the features of, not only excellent image quality and stability, but also productivity and cost, and is expected to be predominant among color print systems.

FUJICOLOR CRYSTAL ARCHIVE PAPER TYPE ONE is a silver halide color paper designed for digital printers. This color paper allows the attainment of higher print quality than ever before. The features of this color paper are described below.

(1) Enhanced Suitability to High intensity Laser Exposure

With enhanced suitability to high intensity laser exposure, this color paper is able to produce consistently high-image-quality prints with rich gradation extending from highlights to shadows.

(2) Improved Image Stability

Boasting of the world's highest level of image stability, this color paper provides beautiful prints, which are kept unchanged for a long time not only in dark places, but also in bright ones.

(3) More Brilliant Whites plus Clearer and Distinct Highlights

This color paper provides brilliant whites that will stand the test of time, as well as clearer and more distinct highlights than ever before.

(4) More Consistent Quality under Various Processing Conditions

This color paper is provided with improved consistency of print quality owing to its enhanced processing stability under various conditions especially under those with low processing utilization and with diminished activity of processing solutions as the extremes.

By using above technologies, performances as photographic materials are enhanced extremely. The quality of prints using silver halide system has more advantages compared with that using ink jet system in respect of not only dye image stability typified by hue stability, Ozone gas resistance, light and humidity storage, but also image defects (Figure 1).

This report describes the technologies developed to realize the above-mentioned high performance of FUJICOLOR CRYSTAL ARCHIVE PAPER TYPE ONE.

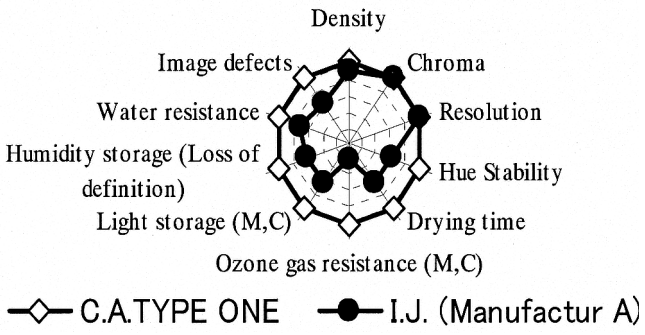

Figure 1. Performances of Photo Materials

Improvement in Technology for High-Intensity Laser Exposure

High-intensity laser exposure for about 10^{-7} second per pixel is carried out in the Digital Minilab Frontier. Silver chloride emulsions used in color papers are inclined to exhibit high intensity reciprocity law failure, owing to which the emulsions suffer from inefficiency of latent image formation when exposed to high-intensity light. In order to solve this problem, Ir-dopants were introduced into silver halide grains as traps for photoelectrons. A photoelectron stays at an Ir center for a certain period and is then released by it. These processes are repeated many times before a photoelectron is trapped by a sensitivity speck, resulting in the improvement of high intensity reciprocity law failure. Since the above-stated processes prolong the process of latent-image formation, they bring about the growth of image centers during the time interval from exposure to processing. This is regarded as the problem of latent-image stability, which prevents the production of stable digital prints. We succeeded in precisely controlling the doping sites of Ir centers in a silver halide grain to solve the latent-image stability problem, and in achieving the stable latent-image performance on high-intensity laser exposure even during the time interval of several seconds from exposure to processing.

Image Stabilization Technology

For print materials, it is very important to keep their high-quality images stable under various conditions for a long period of time. Storage conditions are roughly divided into two. One of them is so-called "dark storage", which is equivalent to the storage in an album affected by heat and humidity, and the other is so-called "light storage", which is equivalent to the storage in an exhibition state affected by visible and UV light. FUJICOLOR CRYSTAL ARCHIVE PAPER TYPE ONE as well as the former FUJICOLOR CRYSTAL ARCHIVE PAPER achieved the dark storage stability at the world highest level. A significant improvement was made in the light storage stability. When a print is exhibited in the direct rays of the sun, the surface temperature of a print is elevated by the sunlight. On the other hand, the surface of a print is room temperature when it is exhibited indoors. Recently, it is found that the light storage stability of the color paper depends on the temperature, at which it is displayed (Figure 2). As the surface temperature was lowered, the fading rate was decreased except low-density part of the yellow. Only low-density part of the yellow has the opposite temperature dependence. Surface temperature of color print is one of the most important factors when we discuss light stability. Especially we must take care of the balance of the fading rates of 3-colors. The light storage stability of FUJICOLOR CRYSTAL ARCHIVE PAPER TYPE ONE at the normal room temperature, which corresponds to the temperature for indoor exhibition, was improved by HDS (Hybrid Dye-image Stabilizing) Technology. Experiments on the practical conditions of 500 Lux or less showed the excellent effect of HDS. This technology improves the stability of currently used anti-fading agents, and keeps them effective over the longer period of time than ever before. Thereby, the light storage stability of yellow dyes at the highlights of this paper was improved significantly.

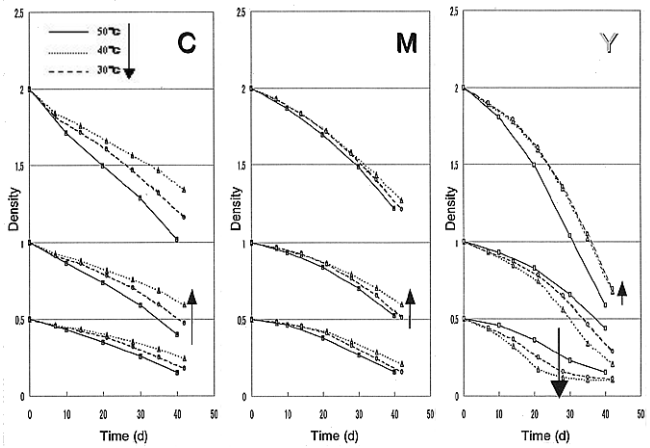

Figure 2. Light keeping (Influence of Surface Temperature) Color Paper (Current Type) was irradiated with Xe light of 100klux from 35 to 50 degree centigrade for 6 weeks.

Technology for Improving Whiteness

The improvement in whiteness in a color print is important in order to make its highlights clearer and more distinct than before. The main causes for the deterioration of whiteness are the formations of emulsion fog and residual dyes.

(1) WE (Whiteness Enhancing) Technology

Color papers usually contain large amount of water-soluble irradiation-neutralizing dyes in order to improve image sharpness. However, the insufficiency in washing keeps a part of these water-soluble dyes remain in a print, and deteriorates the whiteness. We developed and introduced new water-soluble dyes, which could be washed out rapidly even when washing was not sufficient.

(2) RR (Resistance to Radiation) Technology

Silver halide grains in color papers suffer from gradual fog formation owing to their exposure to environmental high-energy radiation, and are thus inclined to cause the deterioration of whiteness on their prolonged preservation. The rate of fog formation due to the environmental radiation increases with increasing the average size of the grains, and is therefore the highest in a blue-sensitive emulsion layer among three emulsion layers in a color paper, since it contains the biggest silver halide grains among them. Consequently, the white ground in a color print is inclined to be colored yellow. We succeeded in reducing the average size of silver halide grains in a color paper without reducing their sensitivity by means of new chemical sensitization technology, and thereby, in remarkably improving the whiteness on their prolonged preservation.

Processing Stability Improvement Technology

It has been an important subject to realize stable photographic properties under such conditions as slack-period processing. We developed the emulsion technology, which provided color papers with very stable photographic properties regardless of the change in the degree of fatigue of processing solutions with change in the concentration of their components.

The processing stability of an emulsion in a color paper is enhanced by the increase in the rate of its development. We therefore focused our efforts to the following points in order to increase the rate of the development.

(1) Reduction of Internal Defects

If defects are formed in the interior of silver halide grains, they capture photoelectrons to form internal latent image centers. Since a developing solution gradually dissolves the grains with latent image centers in the interior, it develops the grains when it reaches the centers, and thus slowly increases the number of developed grains as the development proceeds. We newly developed the grain-forming method, which prevents grains from forming internal defects, and depress the formation of latent image centers in the interior of the grains.

(2) Reduction of Grain Size

It is known that the rate of development increases with decreasing the average size of silver halide grains in color papers, since the development of the grains proceeds in parallel with nearly the same rate in terms of the amount of developed silver per unit time. However, sensitivity usually decreases with decreasing the average size of the grains. It is therefore necessary to increase the efficiency of latent image formation in order to increase the rate of development by decreasing the average size of the grains without deterioration of sensitivity. We developed the new chemical sensitization technology, which increases the efficiency of latent image formation. This technology is the same as the above-mentioned RR technology.

Conclusion

FUJICOLOR CRYSTAL ARCHIVE PAPER TYPE ONE is provided with many desirable aspects in its performance as the results of the improvements caused by the introduction of many new technologies as described in this report, especially with high-image-quality when it is used with the Digital Minilab Frontier.

Biography

Shin Soejima, graduated from Science University of Tokyo, graduate school of science, receiving master's degree in electrical engineering in March of 1994. His specialty is the physical chemistry of surface-active agent. From April of 1994 to date, he has been employed by Fuji Photo Film Co., Ltd. at its Ashigara Research Laboratories, and engaged in research regarding silver halide color paper especially development of novel functional materials.