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New Light Stability Technology in TA Paper

Shojiro Sano, Kazumori Minami, Akira Igarashi
and Masanobu Takashima
Fujinomiya Research Laboratories of Fuji Photo Film Co., Ltd., Shizuoka, Japan

Abstract

A new direct thermal full color recording system named "TA" (Thermo Autochrome) has been developed. The TA system creates high quality continuous tone full color prints without any accompanying wastes such as an ink ribbon or an ink cartridge. In addition, the color image remains stable when coming in contact with oil and plasticizer. This is because the color image of TA paper is formed within the microcapsule directly on the base paper with no transfer of coloring agents.

In this paper we will describe the light stability improvement technology for TA paper. Cutting ultraviolet light by introducing an ultraviolet absorber precursor layer which forms an ultraviolet absorber by light exposure on the color forming layer is effective. Cutting oxygen by adding a low oxygen permeability layer between the color forming layer and the basepaper is also effective in improving light stability. Utilizing these two technologies, we have succeeded in developing a new type of TA paper which has superior light stability .

Introduction

Recently we have developed a new direct thermal full color recording system named "TA" (Thermo Autochrome) that can produce prints comparable to D2T2 in image quality.

TA paper consists of a base paper coated with cyan, magenta and yellow color forming layers. Because TA paper synthesizes color itself, the TA system needs no ink ribbon, ink cartridge or other disposable supplies. However, at the same time this characteristic of TA paper is a cause of inferior light stability especially in the background coloration. We will describe a new technology in TA paper that greatly enhances its light stability.

Mechanism of Image Formation

A simplified cross-sectional view of the TA paper is shown in Figure 1. The outermost layer is a heat-resistant protective layer. The yellow color forming layer is comprised of a microencapsulated diazonium salt compound, an organic base, and a coupler which react to form a yellow azo dye. The magenta color forming layer is comprised of a microencapsulated diazonium salt compound, an organic base, and a coupler which react to form a magenta azo dye. The innermost color forming layer is comprised of a basic leuco dye and a phenolic compound developer which react to form a cyan dye.

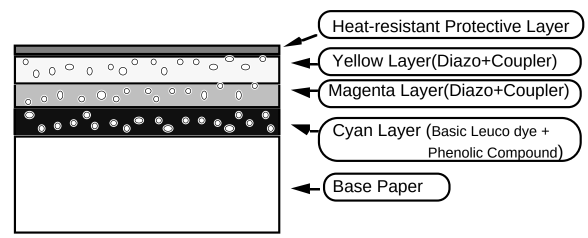

Figure 1: Simplified cross-sectional view of TA paper

A full color print is obtained in a five-step process with the TA system as shown in Figure 2. First, the yellow color forming layer reacts to low levels of thermal energy to generate the yellow portion of the image. Second, the entire print is exposed to a 420nm ultraviolet lamp, which decomposes the diazonium salt compound remaining in the yellow color forming layer. Third, the magenta color forming layer reacts to mid-range levels of thermal energy to generate the magenta portion of the image. Fourth, the entire print is exposed to a 365nm ultraviolet lamp, which decomposes the diazonium salt compound remaining in the magenta color forming layer. Finally, the cyan color forming layer reacts to high levels of thermal energy to generate the cyan portion of the image.

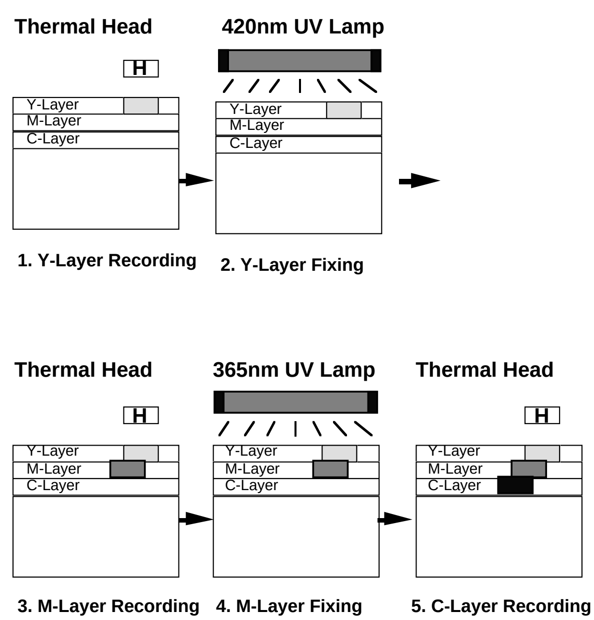

Figure 2: Image -forming process by the TA system

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A diazonium salt compound is an indispensable color forming material for TA paper. It gives both thermo-sensitivity and fixable properties to the yellow and magenta color forming layers. However, a diazonium salt compound has a high reactivity level and tends to react with a coupler even at room temperature. To avoid this unprefereble reaction, the diazonium salt compound is dissolved in oil and microencapsulated. The diazonium salt compound is isolated from the coupler and the organic base completely by the capsule wall which provides good stability over a long time of period. The capsule wall material of the microcapsule in TA paper is poly(urea/urethane). It is known that a poly(urea/urethane) microcapsule becomes permeable above its glass transition temperature(Tg). When the color forming layer is heated above the Tg of the capsule wall, the coupler and the organic base instantly permeate the wall and react with the diazonium salt compound.

Introducing an Ultraviolet Absorber Precursor Layer

Introducing an ultraviolet absorber layer on the color forming layer is effective in improving light stability. However, in the TA system this countermeasure can not be used because the ultraviolet absorber obstructs the decomposition of the diazonium salt compound with an ultraviolet lamp. Figure 3 shows the reflective optical density of the magenta color forming layer as a function of the exposure time to a 365nm ultraviolet lamp . With an ultraviolet absorber layer, the diazo salt compound slightly decomposes after exposure to an ultraviolet lamp and causes an undesirable color forming reaction.

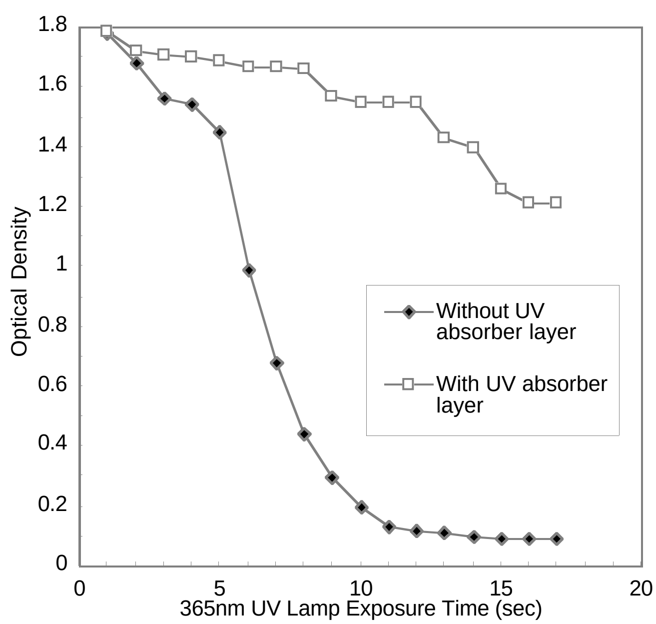

Figure 3: Effect of the urtlaviolet absorber layer for the magenta color forming layer fixation.

To resolve this problem we developed an ultraviolet absorber precursor. The ultraviolet absorber precursor does not absorb ultraviolet light before exposure to light because of the exsistence of a protective group such as a sulfonyl group. After exposure to light, the sulfonyl group is eliminated and the remainder converts to an ultraviolet absorber. The typical ultraviolet absorber precursor and its conversion scheme to the ultraviolet absorber is shown in Figure 4. In this reaction the hydrogen donor plays an important role. The comparison of the spectrum change of the ultraviolet absorber precursor with or without the hydrogen donor when exposed to a Xenon lamp (390W/m2) is shown in Figure 5. With the hydrogen donor the ultraviolet absorber precursor converts rapidly to the ultraviolet absorber by exposure to light. Therefore, the ultraviolet absorber precursor layer improves light stability. Examples of a hydrogen donor include hydroquinone compounds, hydrazide compounds, phenidone compounds, phenol compounds, and ascorbic acid compounds. The ultraviolet absorber precursor and hydrogen donor are dissolved in an oil and microencapsulated to prepare an ultraviolet absorber precursor layer.

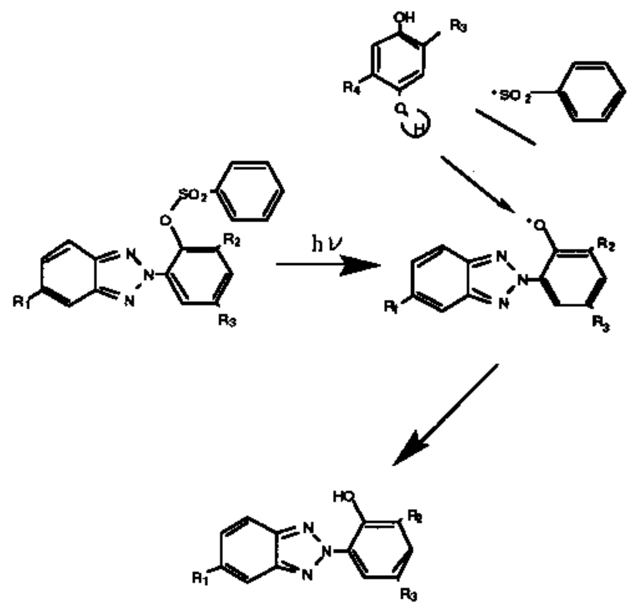

Figure 4: The typical ultraviolet absorber precursor and its conversion scheme to the ultraviolet absorber

Introducing an ultraviolet absorber precursor layer is effective in improving both image light stability and background coloration as shown in Figure 6. Image light stability is almost completely improved. However, background colorlation is not yet satisfactory. Even if ultraviolet light is completely cut out, background coloration still occurs by exposure to visible light.

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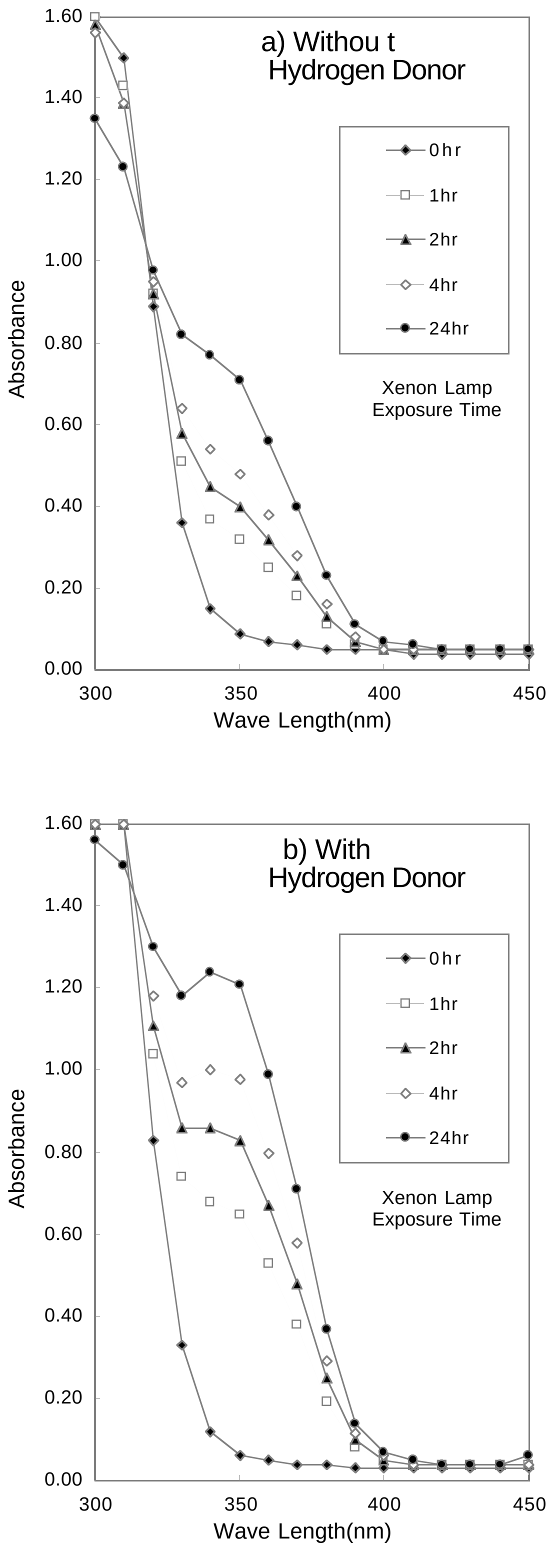

Figure 5: The comparison of the spectrum change of the UV absorber precursor with or without the hydrogen donor.

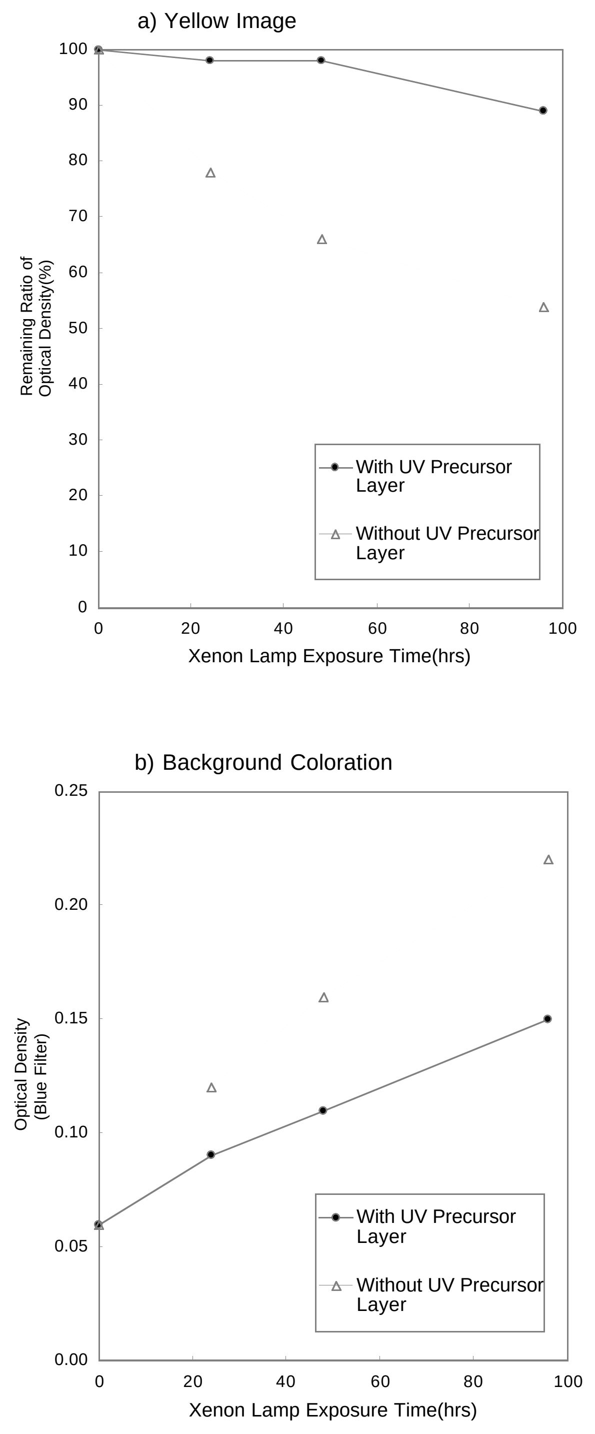

Figure 6: Improvement of light stability by introducing an UV absorber precursor layer. a) Yellow image light stability; b) Background coloration

Adding a Low Oxygen Permeability Layer

To prevent a photooxydation reaction we tried to cut oxygen exposure by adding a low oxygen permeability layer between the color forming layer and the basepaper. Figure 7

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shows a relationship between background coloration and oxygen permeability of a basepaper with a layer consisting of various kinds of polyvinylalcohol. Adding a low oxygen permeability layer is effective in improving background coloration.

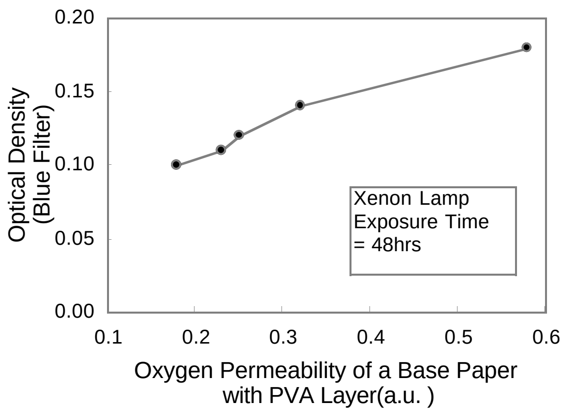

Figure 7: Relationship between background coloration and oxygen permeability

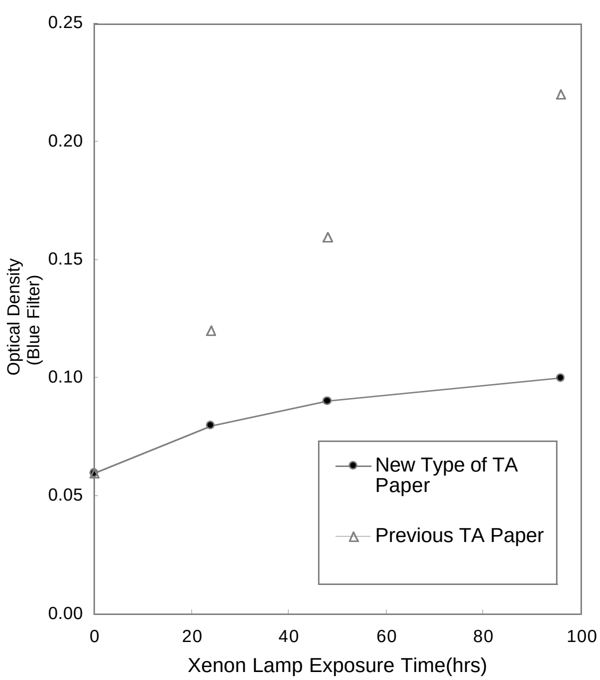

Figure 8: Background coloration of a new type of TA paper

Figure 8 shows the background coloration of a new type of TA paper with an ultraviolet precursor layer on the color forming layer and a low oxygen permeability layer between the color forming layer and the basepaper. Even if TA paper is exposed to light for a long period, both discoloration of the image and coloration of the background are very slight. Figure 9 shows a simplified cross-sectional view of this new type of TA paper.

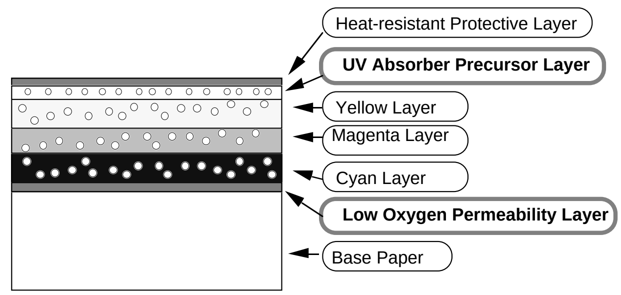

Figure 9: Simplified cross-sectional view a new type of TA paper

Conclusions

Utilizing two technologies, cutting ultraviolet light by introducing an ultraviolet absorber precursor layer and cutting oxygen by adding a low oxygen permeability layer, we have succeeded in developing a new type of TA paper with superior light stability . We began selling this new type of TA paper May in 1997, it has been well received because of its superior light stability, chemical resistance and eco-friendliness.

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