Application of Thermal Printing Technology for Security Printing

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Abstract

Direct thermal and thermal transfer printing methods can be used for creating documents with embedded permanent images and texts as security codes, which are visible only under ultraviolet light. Copying or scanning of the documents cannot reproduce these images. Such documents can be created by direct thermal printing of single sheets, containing single or multi-layer coatings of image forming components, by single or multi-pass printing. A combination of direct thermal and thermal transfer methods can also be used for generating similar documents by single-pass printing.

Single sheet direct thermal process, in which the printed images gradually fade with time, can be used for creating documents for temporary identification. The length of time required for such fading can be controlled by proper selection of the components of the imaging systems.

Introduction

The demand for documents, which contain security codes that cannot be altered or duplicated, has been increasing during recent years. These security codes can be watermarks, or images that are only visible when exposed to ultraviolet light. Temporary identification documents are also useful when they are valid during a limited period of time.

Several papers have been published recently, in which electrophotography, inkjet and thermal printing methods have been used for printing security documents [1-5], containing embedded images, which are visible only under special conditions. These processes include images generated by using fluorescent dyes in ink-jet systems [3], and also by thermal dye transfer [2]. The present paper describes several systems, based on thermal transfer and direct thermal imaging systems, and combinations of the two, which can be applied for generating security documents. These systems can be used for creating documents containing security codes, as well as thermally generated images, the fading time of which can be controlled.

Applicable Thermal Imaging Systems

The thermal imaging systems, which can be used for generating security documents by thermal printing methods, are described below.

Thermal Transfer Imaging Systems

In a previously published paper thermal transfer of fluorescent dyes for creating security documents has been described [2]. In a different type of thermal transfer system, dyes with good film forming properties are coated with crystalline thermal solvents on donor sheets [6]. During imaging process the thermal solvent melts and dissolves the dye, and the combination is transferred onto a porous receiver sheet. When a dye is replaced by a uv-absorbing material, which also forms a film, the transferred image is visible only when viewed under ultraviolet light (commercially available as 'black light'). Such images are embedded in documents containing visible colored images from thermally transferred dyes from other donor sheets.

Direct Thermal Imaging Systems

A new direct thermal system, described in Figure 1, consists of more than one dye layers coated on a single sheet [7, 8].

Thermal topcoat
High melting color-forming layer
Thermal insulating layer
Intermediate melting color-forming layer
Thermal insulating layer
Low melting color-forming layer
Substrate

***Figure 1**.Structure of a direct thermal printing medium capable of rendering full-color images.*

The color-forming layers are separated by thermal insulating layers. Full-color images are generated by optimizing the duration and intensity of energy applied to each layer. The uppermost color-forming layer, which requires temperature higher than that required for the other layers, is exposed to the required temperature for a short duration of time. The insulating layers decrease the rate of conduction of heat and thus prevent the color formation in the other layers. For imaging the lower layers, less energy is applied to the sheet but for longer durations, thus allowing transmission of heat to those layers. This type of system can be used for generating visible as well as secure images, by replacing one of the color-forming layers by a uv-absorbing material, which has the same melting temperature range as the color-former. The visible image is generated by thermally induced chemical changes of the color-formers, and the uv-visible image or the watermark is created by changing the covering power of the uv-absorber. The uv-absorber, coated as dispersed solid particles, will have greater covering power in the exposed regions than in the unexposed regions due to melting of the particles. When viewed under ultraviolet light, the exposed regions would appear darker than the unexposed regions. An example of a system, consisting of a lower melting uv-absorber and higher melting color formers is shown in Figure 2. In this system a uv-visible image is embedded in a visible image generated from the two color-forming layers. In a simplified version one of the color forming layers can be eliminated for creating a document containing a visible monochrome image and a uv-visible image.

Thermal topcoat
Higher melting color-forming layer
Thermal insulating layer
Intermediate melting color-forming layer
Thermal insulating layer
Lower melting uv-absorbing layer
Substrate

***Figure 2**. Structure of a direct thermal imaging system capable of generating an invisible image embedded in a colored image*

Amorphochromic materials, which are colorless in crystalline form, but are colored in amorphous form, are used in these systems [9]. The change occurs during thermal imaging process, as shown in Figure 3.

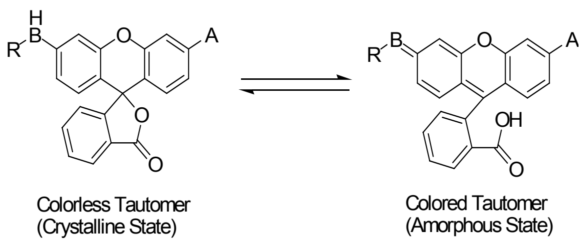

***Figure 3**. Colored and colorless forms of an amorphochromic color-former*

The mechanism of generating color in this system is also suitable for creating temporary identification documents. The colored form can be reverted to the colorless crystalline form under suitable conditions. The presence of a material that would lower the glass transition temperature of the color-former can cause the amorphous colored form to crystallize even under ambient conditions, and cause the fading of printed images. The apparent rate of fading of a printed image can be controlled by the nature and level of the additives. Figure 4 shows an example of the effects of various additives on change of printed density with time.

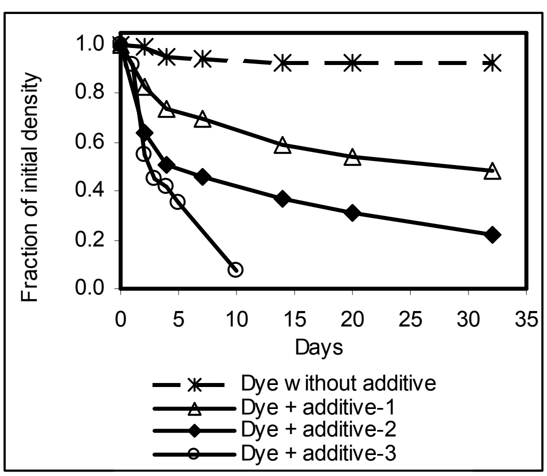

***Figure 4.** Effects of additives on printed images under ambient conditions*

Images in this type of direct thermal system can be generated by a single pass or multi-pass printing method. As mentioned earlier in this section, the intensity and duration of energy applied to the coatings are controlled for activating each of the layers separately for clear separation of the images generated in each layer.

Combinations of Thermal Transfer and Direct Thermal Imaging Systems

Combinations of thermal transfer and direct thermal imaging systems can be applied for generating security documents containing colored and embedded images, as well as watermarks.

In one such system a donor sheet containing a uv-absorbing material, which is also a film former, is transferred onto a substrate, which contains a thermally image forming system, such as a leuco dye and a developer [10]. The image from the leuco dye is visible under ambient light, and the image from the transferred uv-absorber would be visible as embedded image only when viewed under ultraviolet light. Another method consists of the transfer of a visible dye onto a substrate containing a uv-absorbing material. As described before, the covering power and consequently the spectral absorption of the uv-absorbing material would increase due to melting and make the exposed regions visible under ultraviolet light. In this case, the visible image will be due to the transferred dye, and the invisible embedded image or the watermark would be generated from the coatings in the receiver sheet. Single pass printing can be used for both these systems.

In general, images created by thermal processes have good moisture resistance, which is an important factor for security documents. The security documents can also be encased under clear sheets containing optical brighteners. This will lead to the images generated from the uv-absorber be visible under ultraviolet light only when the cover is removed, which will make the document more tamper resistant.

Conclusions

Thermal imaging systems can be used effectively for creating security documents containing colored images with embedded images, visible under ultraviolet light. Thermal transfer systems, direct thermal imaging systems, and combinations of the two are suitable for such applications. A new type of single sheet multi-layer direct thermal imaging system can also be used for generating documents for temporary identification, in which the printed images fade with time under ambient conditions. The fading rates of such prints can be controlled by proper selection of the components of the imaging system.

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Fariza Hasan, employed at ZINK Imaging, LLC. in Massachusetts, received her PhD. in chemistry from University of British Columbia, Canada. Her graduate and post-doctoral research included kinetics and mechanisms of inorganic, organic and biochemical reactions. The technical responsibilities in her current and previous positions consist of optimization and design of silver halide and digital imaging systems. She has a total of approximately forty scientific publications and patents, and is a member of the IS&T and American Chemical Society.