The Pursuit of Camera Speed Color Films Based on Photothermographic (Dry) Technologies

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Abstract

New technologies will need to be discovered in order to satisfy consumer film imaging needs for both rapid image access and available-everywhere film photofinishing. Fortunately, the film technologies that drive rapid image processing are also the same technologies that form the basis for relatively inexpensive, self-operated, highly distributed photofinishing systems for consumers.

Central to such concepts are camera speed films that can be thermally processed for very short times (less than 10-20 seconds). Photothermographic (PTG) technologies could circumvent the major obstacles associated with current conventional photofinishing, which relies entirely on wet chemistries.

The authors have examined the potential of new PTG technologies to provide the photographic sensitivity and raw stock stability required for a consumer color film. Our conclusion is it might be possible to meet such requirements with newly discovered technologies.

Introduction

A remaining, significant challenge to photographic scientists is the realization of high photographic sensitivity in thermally processable, silver halide-based image recording materials. New output systems such as the Kodak DryView laser imaging system have provided important opportunities in the health imaging businesses. Unfortunately, the sensitivity of such recording materials is several of orders of magnitude less than that required for direct image capture, and the easy translation of such technologies to image capture is not straightforward.

Figure 1 compares the sensitivity of a camera speed film to that available from dry processable systems that have been developed for hard copy output.

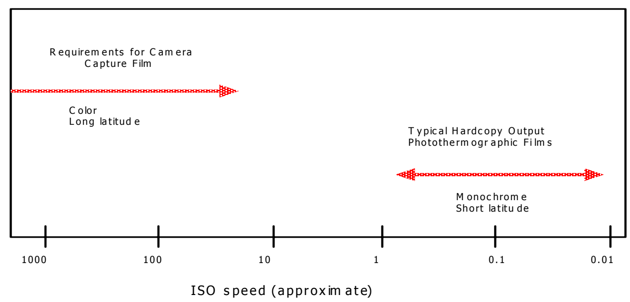


Figure 1. Requirements for image capture vs output films.

A number of significant challenges must be met in order to consider a silver halide film imaging system that is capable of very rapid image access times and is accessible nearly everywhere. An ideal system would be one where all of the imaging chemistry is integral to the film, and the film element serves as the image recording and chemical image-processing unit and can be easily developed in its dry state via thermal energy. In a system based on thermal processing, the most critical limiting factors appear to be: 1) absolute photosensitivity, 2) raw stock stability, and 3) image acquisition and delivery. This paper addresses the first two factors.

Methodology and Experimental Approach

Initial experiments were conducted to assess the utility of camera-speed tabular-grain emulsions when incorporated in solvent-based formats typical of black and white (B&W) PTG recording films, such as microfilm and Kodak DryView film. Upon dry processing these experimental B&W film formats exhibited sensitivities insufficient to be considered for camera speed PTG films. The inability to conduct efficient color formation was another important limitation.

Several gelatin-based color-forming film formats were evaluated to establish a perspective on other available technologies and to identify gaps that exist. Two basic single-layer film formats were explored; the PTG format was designed for high temperature (dry) processing (>100 °C), and the other single-layer format was used for the standard Process C-41. The negative-working PTG film format incorporated all of the necessary color imaging chemistry, i.e., silver halide emulsion, silver donor (salt), antifoggant, magenta color coupler, and free-to-react (or free) color developer; the wet (Process C-41) film format contained emulsion and magenta color coupler. In order to assess the potential for maximum sensitivity, sulfur plus gold-sensitized high-speed tabular emulsions were used in both formats. A drum processor was used to develop the PTG films at 130 °C, while Process C-41 was used for processing of the more conventional negative-working film element. New technologies were identified and tested as the need arose.

Results and Discussion

The sensitivities and raw stock stability for each pair of film and processing combinations are compared in Fig. 2 (PTG format is also shown). The sensitivity of the PTG film is seen to be within about a stop (0.30 log E) of the Process C-41 film and, thus, could be considered photosensitive enough for camera speed applications. Although the PTG format (with incorporated but free CD-4) exhibited speed sufficient for direct image capture, its raw stock stability was deemed unacceptable for any reasonable consumer film application.

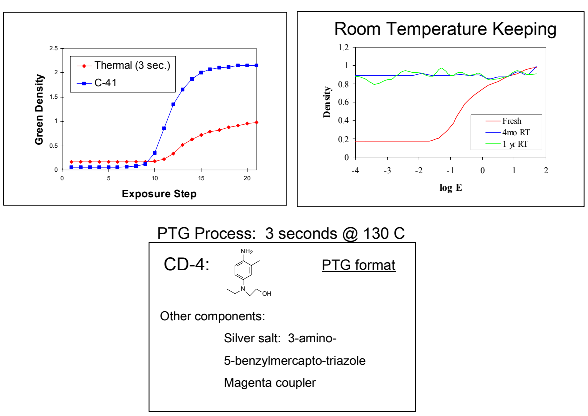
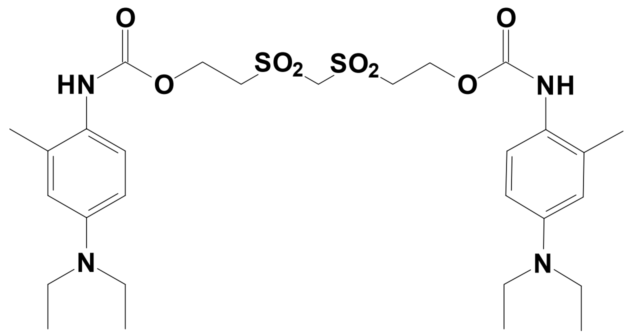


Figure 2. Comparison of PTG (CD-4 incorporated) and Process C-42 formats (CD-4 as provided in that process).

Approaches to overcome the inferior raw stock stability seen in the PTG film format containing free color developer included: 1) discovery of a blocked form of the color developer to promote reaction with coupler under more defined conditions and at higher process temperatures while reducing activity during keeping, and 2) the development of a more compatible set of silver donors for the higher temperature processing to optimize the availability of silver ion for imaging efficiency, image discrimination, and raw stock stability.

Classes of novel blocked color developers were created.[1,2]. These new developers enabled higher process temperatures and provided high image discrimination, good color-forming properties, and good raw stock stability. An example of one such developer is illustrated below.



This blocked developer, when used with the silver donor combination,[3,4] below in Fig. 3, provided a PTG element that exhibited a variety of important properties, which suggest that both high sensitivity and good raw stock stability might be possible.

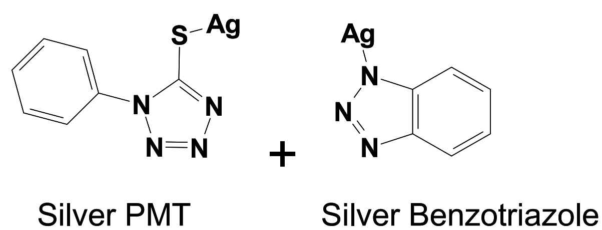


Figure 3. Silver donor combination for high temperature dry processing.

Results from experiments utilizing the new blocked developer and silver donor combination are shown in Figs. 4–5. In a number of instances the images created with the PTG film were followed by bleach and fix steps to remove developed silver and residual silver halide to facilitate evaluation.

Density Formation in Dry (PTG) Films with Blocked Developer Chemistry

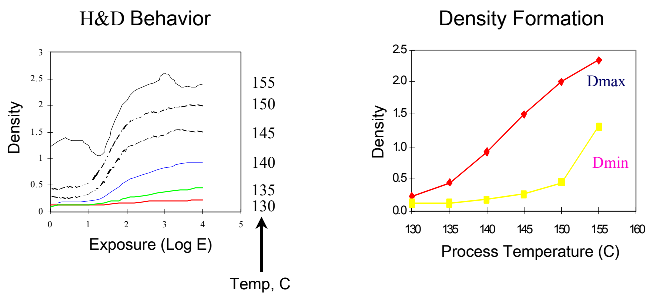


Figure 4. Image discrimination as a function of PTG process temperature.

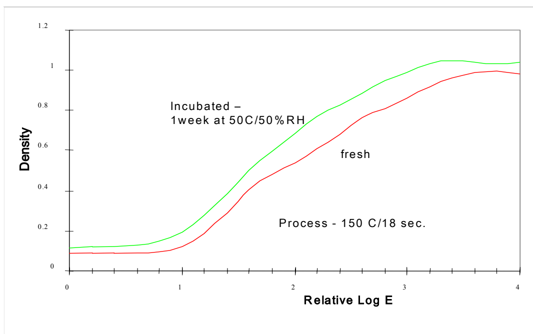


Figure 5. Raw stock stability of PTG element with new blocked developer and silver donor combination.

A series of high-speed tabular grain emulsions was evaluated in the new blocked color developer format to determine the photographic sensitivity relationship of the PTG and standard Process C-41 film formats. These results are shown in Fig. 6. The graph illustrates that the PTG film element remains within about 1 stop of the Process C-41 format over the size range explored, thus, providing further evidence that camera speed is possible.

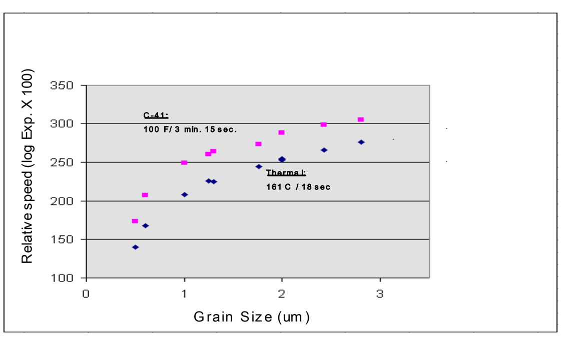


Figure 6. Speed vs grain size; PTG and Process C-41 formats

Summary

Innovations in PTG film technology have the potential to provide new consumer color film system opportunities. New PTG camera speed films could provide rapid image access through highly dispersed photofinishing systems that rely on simple and rapid dry processing, scanning, digital image processing, and image presentation (soft display) or hard copy output. Films based on PTG technologies could be expected to work within existing cameras. The technologies that enable rapid film image access are the same technologies that allow for dispersion of this mode of photofinishing to virtually anywhere that has electricity.

References

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Biography

Dr. Gary L. House received his Ph.D in Chemical Engineering from the University of Illinois at Champaign-Urbana in 1977. He joined the Research Laboratories of Eastman Kodak Company that same year. His research interests at Kodak have included silver halide emulsion science, color film design, hybrid imaging systems, and ink jet technologies. After many years in management he is currently a Distinguished Research Fellow at Kodak.

He is a Fellow and Senior Member of The Society for Imaging Science and Technology, and has enjoyed the opportunity to both organize and participate in past East-West Symposia.