

Sensitometric Effect of Pre-exposure Heating on Thermally Developed Photographic Materials

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Abstract

The decrease in the sensitometry properties of thermally developed photographic materials subjected to pre-exposure heating, is related to the presence of toners in the photolayer. It is shown here that the addition of the developer to the photolayer and toners to the protective layer improve the sensitometry in a two-layer construction.

Introduction

Thermally developed photographic materials (TDPM) based on admixtures of silver halides and silver carboxylates make up a complex system aimed at optical recording and its visualization in a thermal development process. Regardless of the fact that the TDPM functions in a manner similar to classic silver halide photographic materials, it has some distinctive peculiarities which affect both the latent image formation process and its development. Unlike classical photographic materials, in which the photosensitivity of the photolayer [1] is increased by heating at 100°C for 20 minutes, the TDPM begins to lose development selectivity within 2 seconds of pre-exposure heating (PH) at 115°C. Such behavior of the TDPM is related to the toners being located in the photolayer which either lose their activity or affect the latent image development centers [2] when subjected to PH.

The aim of this paper is to study the PH action on the sensitometry of the TDPM samples comprised of a photo- (lower)- and a protective (top)-layer, in which toners and developers are contained in different combinations.

Experimental

The photolayer was obtained by methods previously published [3]. The films contained silver stearate, silver bromide, stearic acid, an optical sensitizer and polyvinylbutyral resin (PVB). The protective layer was obtained from 2.5 % PVB solution in isopropyl alcohol. Prior to coating the following starting solutions were added in 100 ml.: a sterically hindered bis-phenol developer – bis-alcophen (15 ml. of 12 % alcohol solution) and toners – phthalimide (2 gr.) and succinimide (12 ml. of 5% solution in acetone).

Presence or absence of the investigated components in the photolayer and the protective layer were varied. The protective layer was coated on the photolayer after it had dried. Drying of the layers was carried out in air. The photolayer thickness was 8 microns, and the protective layer was 2 microns. Lavsan film was the substrate.

The samples were subjected to PH of different durations, exposed in a FSR-41 sensitometer and developed. Optical step wedge densities were measured with a DP-1M densitometer. The temperature of PH and development was 115°C.

Results

Optical densities of the 5th step of the step wedge, (D_{image}), Fog (D_o) and [$D_{image} - D_o$], were evaluated to characterize the nature of the development process of each sample. The data show a PH influence on sample sensitometry containing the developer in the protective layer and samples with the developer in the photolayer.

Analysis of the data show that the Dimage maximum of 1.7-1.8 is achieved in samples containing the phthalimide toner in the photolayer. All samples subjected to PH are greatly affected. One exception is the sample without the toner components in the photolayer during the PH. In this case, there is only a small PH reaction.

Two samples, 5 and 5a, having an optical density of more than 3.0 are quite clearly different. These samples have a similar content and contain the developer in the photolayer and the toners in the protective layer. Sample 5a, however, was subjected to PH before being over-coated with the protective layer, while sample 5 was subjected to PH alongside the protective layer. The fact that sample 5a was less affected by the PH can be attributed to the absence of toners in the photolayer penetrating the photolayer from the protective layer during the PH process.

Discussion

These results, as those published earlier [2], show that pre-exposure heating of TDPM containing toners (succinimide and phthalimide), regardless of their placement (in the photo- or in the protective layer), cause a decrease in the optical densities and a lowering of the discrimination between the developing processes. Exclusion of the toners from the photolayer and adding them into the protective layer raised the sensitometry of the samples but did not reduce the effect of PH observed with the samples heated in the absence of toners.

The observed phenomena can be explained with the following proposals related to the existence of an epitax in the TDPM photolayer. The epitax consists of a silver

carboxylate and silver halide interface [4] which is isolated from the carboxylic acid in the PVB medium. This epitax obtains a negative charge due to photolytically generated bromide. The bromide is proposed to accelerate the development process by attracting positively charged silver ions. The silver ions are suggested to be comprised of positively charged toner complexes of silver stearate [5,6].

The stearic acid is melted in the pre-exposure heating process, the toners penetrate to the epitax and form positively charged silver complexes. In the unexposed portion of the film the extracted bromide remains bound by the AgX so that a negative charge at the center of the latent image is not formed and the development process proceeds only slowly within the exposed epitax.

The data obtained prove the assumption that pre-exposure heating leads to both a decrease in optical density and a decrease in selectivity of the development process for all samples containing toners in the photolayer or in the topcoat protection layers. Excluding the toners from the photolayer resulted in an increase in the sensitometry for sample 5. The increase is related to the beginning of the development process where there are no toners and the exposed epitax kept its charge. After the toners get from the protective layer to the reaction sites, they enable the reaction to continue at a high speed. Pre-exposure heating of sample 5 caused a greater reduction of sensitometry as it was going on. Samples 4a and 5a were heated without any toners before the protective layer was coated. The resulting PH effect on these samples was considerably less and could be seen as some reduction of the development speed. This latter effect can be associated with various changes of the photolayer physical properties such as solvent removal, stearate acid melting etc.

Conclusions

Reduction of sensitometry under the influence of pre-exposure heating is determined by the presence of toners in the photolayer. Sensitometry of TDPM are considerably increased with the toners excluded from the photolayer and their addition to the protective layer. We connect the toner action with their neutralization by the formation of negatively charged silver carboxylate complex compounds in the exposed, light-sensitive epitax of silver halide and carboxylate.

The results obtained show that a negative charge may exist at the latent image center. In addition, the negative charge is proposed to accelerate the development process.

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