DYE DIFFUSION TRANSFER PROCESS

PROCESS

An integral film consists of a negative layer and a positive layer, separated by a pod. The negative is formed by ten layers: a base, three silver-halide sensitive layers, red, green and blue, a layer of dye-developer on the base side of each layer, interlayers and an anti-abrasion layer. The yellow dye developer layer acts as a yellow filter, preventing blue light from reaching the red and green-sensitive layers [4].

Immediately after the exposition, the film is manually removed from the device: it is pulled through the rollers in the camera to break the small pods attached to the receiving sheet and spread the reagent, a viscous solution of alkali, between the negative and the positive layer [1, 4]. The negative is brought into contact with the positive receiving sheet which contains a dye mordant to ensure the transfer of the dye image. Meanwhile, the reagent swells the negative layer activating and permitting the movement of dye developers into their corresponding emulsion layer. Silver halides that have been exposed are developed via oxidation and become insoluble, trapping the dyes within the negative layers. In unexposed regions, silver halides are not developed and the corresponding dye developers remain mobile. These can be possible because the process of insolubilization of each of the three types of dye-developers is specific to its own layer, and occurs according to different diffusion times [2, 4, 5].

After sixty seconds, the system is neutralized the negative sheet is peeled back to reveal the final image.

Some early films required additional steps by the user, such as swabbing the developed image with a coating to stabilize it or adhering the image to a hard backing to prevent curling [6].

HISTORY

The creation and improvement of instant photography are due to Edwin H. Land.
The instant photography system revolutionized traditional photography by compressing darkroom processes into an integrated film unit and producing a final photograph in the seconds following the click of a camera shutter [6].

Each film unit consisted of a negative, a positive sheet, and a pod containing a viscous fluid reagent needed to start and stop the development of the colour image. After exposure in the camera, the two sheets were pressed together through a pair of rollers, the pod was ruptured. The reagent spread between the two parts of the film to coat the entire surface of the image [7].

The idea of this system was born in 1943, from 1943 through 1946, the instant camera was kept secret at Polaroid's laboratories as multiple challenges were resolved. The entire process required suitable colour intensity and sharpness. The film unit had to be shelf-stable from the time it left the factory to when consumers clicked their camera buttons, and it had to work at a wide variety of temperatures, from desert heat to winter cold. Finally, after development, the unit had to stop all the reactions to create long-lasting photographs. Each problem was solved with precise control of the film's chemistry. In fewer than five years, Polaroid was able to invent and master all the new technologies necessary to make Land's instant system work. The first public demonstration took place on February 21, 1947, during a meeting of the Optical Society of America in New York City, where it achieved resounding success [6].

The first Polaroid camera, the Model 95, and its associated film went on sale in 1948. This model produced only sepia-toned prints and took exactly 60 seconds to process the image. In 1950, a b/w version followed, which, however, required an additional step which involved manual swabbing of the image

developed with a polymer coating to avoid darkening of the photograph [6].

From the late 1950s, Polaroid carried out studies for the development of instant colour films. It was a more complex process than sepia, or b/w printing, as colour photography used three separate negative layers to record colours [6].

By 1962, Polaroid had solved several problems, such as brightening the colour dyes and preparing factories for commercial production; however, image permanence remained an issue. The alkaline developer molecules, necessary for dissolving the dye developers, transferred with the dyes to the positive layer where they would immediately begin to destroy the final image [6]. This problem was solved by introducing acid molecules, within a layer of polymer on the positive sheet where they would react with the alkaline developer molecules the moment after they completed the process of developing the image. When this happened, the acid and base combined, forming water in the film and fixing the dyes in place. Based on this, Polacolor was introduced in 1963 [6].

Although Polaroid was the inventor and the predominant producer of instant materials, other companies attempted to produce them. For example, Fujifilm produced Fuji FP film, very similar to the Polacolor system. The Ektaflex PCT systems by Kodak and Copycolor were also sold. [4]

Until this point, Polaroid films required a step that interfered with Land's vision of absolute one-step photography: After being ejected from the camera, the user had to peel back the negative sheet to reveal the final photograph. Some early films required additional steps by the user, such as swabbing the developed image with a coating to stabilize it or adhering the image to a hard backing to prevent curling [6].

Based upon this premise, Polaroid announced the first "Absolute One-Step Photography" system in April 1972, the SX-70. The development of this system required a complete reformulation of the Polaroid system. Specifically, since the product was integral, negative, and positive and reagents were all contained within a single unit and at the end of the development process, no separation took place [6].

From 1972 to 2008, Polaroid released a large number of films in various formats, making improvements to the structure and chemistry of these materials. For example, Polaroid Time-Zero films, introduced in 1980, had different development times and a different structure of layers. Polaroid 600, introduced in 1981, included an anti-fog layer and pigmented interlayers. Spectra films, introduced in 1986, instead combined the development system with the dye release system to better manage the migration of yellow dyes [4].

The internal diffusion transfer of the dye was the process used in Kodak integral films, introduced in 1976 and withdrawn ten years later due to a patent violation lawsuit filed by Polaroid. In this system, the exposure of the silver halides caused the dye release, forming a negative colour image. To obtain the positive image, a positive inversion emulsion was used to process the unexposed silver halides [4]. This system was not only exploited by Kodak, but also by Fujifilm which introduced its version in 1981.

Since 2010, thanks to the Impossible Project (known as Polaroid Original and from 2020 as Polaroid), several integral instant films, designed for Polaroid cameras, were sold [8].

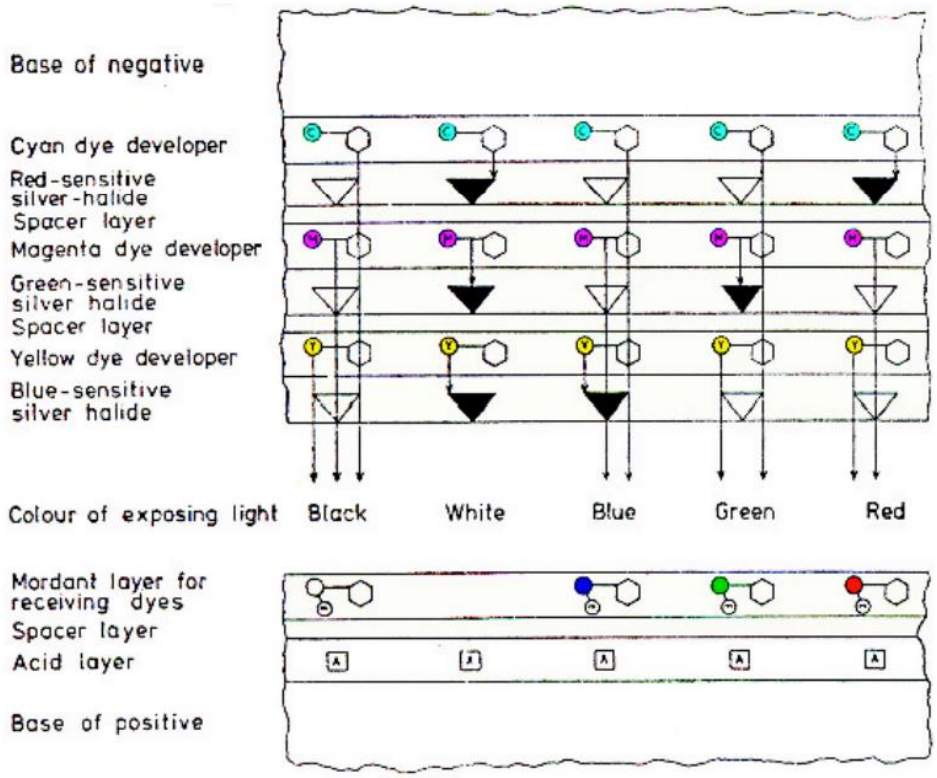

Fig. 1 *Diagrammatic representation of the Polacolor process* [1].

[1] Atelier de Restauration et de conservation des photographies de la Ville de Paris., Lingua Franca: A Common Language for Conservators of Photographic Materials, Ottawa: Library and Archives Canada, 2018.

[2] Image Permanence Institute, «Graphic atlas - Identification - Dye Diffusion Transfer» Rochester Institute of Technology, 2021. [Online]. Available: http://www.graphicsatlas.org/identification/?process_id=111#overview.

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