Ozaphan films: preliminary study on color analysis and digitization

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Abstract

Ozaphan is a historical type of motion picture film made of cellophane, which exploits a silverless printing technique called diazotype used only for positive prints. These films were produced in the late 1920s up to the 1950s, initially in France and later in Germany, catering mainly to the home cinema market and therefore being printed primarily on small gauges. Ozaphan films were intended to be black-and-white films but ended up with a characteristic yellow hue due to the phloroglucinol used in the photosensitive solution.

Although Ozaphan films were produced in relatively small quantities, we still find these prints in many European film archives today. Nonetheless, not much research has been carried out on this film material's conservation and physical characteristics.

This study aims to document Ozaphan's color characteristics by presenting an in-depth color analysis of the latter, achieved mainly through spectrophotometric instrumentation. The measurements have been carried out both on the light parts as well as on the dark parts of the frames to try and identify the exact hues of the yellow tendency of the prints. These types of colorimetric measurements can be firstly a relevant record of the current state of preservation of the films and secondly a reference during digitization and future digital restorations.

Digitization certainly is a valuable tool for preserving and distributing audiovisual heritage. However, it involves modifying or excessively approximating the representation of some intrinsic characteristics of the materials, like colors. Thus, the second step in this study has been the attempt to apply the measurements of the transmittance color values both during scanning and the subsequent color correction phase to digitally preserve the actual hues of the Ozaphan films.

Though still experimental, the results can be a useful hint for the approach to scanning, and the colorimetric measurements are a reference for further studies of Ozaphan films.

Keywords: Ozaphan, Film Restoration, Cultural Heritage, Color in Films

Introduction

The historical origins of Ozaphan films emerged from the convergence of two pioneering inventions: cellophane, a transparent regenerated cellulose foil, and the dry diazotype process, a positive-working reprographic method that involves the photosensitivity of diazonium salts and azo dye synthesis.

During the early 1920s, Société Anonyme Le Cellophane in France conducted experimental endeavors, applying the diazo print process onto cellophane film strips. Subsequently, a more robust framework for Ozaphan film production took shape through a procedural exchange between Kalle & Co. AG and La Cellophane. This agreement permitted Kalle & Co. AG to exploit cellophane in certain regions while enabling La Cellophane to utilize the Ozalid procedure.

In France, the Ozaphan films were first sold in 1928 and in the following years, different gauges were released such as 17,5 mm, 22 mm, 24 mm and 35 mm.

Within Germany, Kalle & Co. AG assumed the exclusive production of Ozaphan film stock and introduced it to the market around 1932 as a 16 mm format for the distribution of a segment of Agfa's home movie catalogue. The Ozaphan catalogues, predominantly encompassing fairytales, documentaries, animation, and comedies, were tailored to family audiences.

From 1934 and 1940, the monthly newsreel series *Schmalfilm Monatsschau* was distributed. These materials were under propagandistic influence, especially after an agreement between Kalle and UFA.

The Ozaphan film production ceased in June 1940 due to cellophane shortage and wartime demands on Kalle's workforce.

After World War II, Germany's film industry faced challenges due to the destruction of establishments and Allied control over distribution. In 1949, a new Ozaphan film program emerged, and a small number of 8 mm films were printed; nonetheless, production issues and the technological advancements of other film stocks led to a fast decline in the late 1950s. This resulted in the discontinuation of the Ozaphan production in 1958.

The process for the production of Ozaphan films can be explained in four steps[5]:

1. Sensitizing: In a dark room, the cellophane sheets were immersed in a light-sensitive solution composed mainly of diazonium cations[6], dye couplers[7], and acid stabilizers; the latter prevents pre-coupling between the couplers and the diazo cations.
   Depending on the color that was to be achieved, different types of couplers could be chosen. A diazo solution can contain more than one coupler which, for example, is necessary to obtain a black image, even though it is not possible to get a dense black.

2. Printing: The exposure of the films happened with a contact printer. The light transmitted through the clear parts of the image, onto the diazo coating, started the photolysis of the diazonium salts. Their decomposition left a clear or light part on the film. On the other hand, where the dark sections of the master didn't allow the light to shine through, the diazo salts stayed intact and maintained their coupling abilities.
3. Developing and toning: The development of the films took place in an autoclave where ammonia gas was introduced. This process made the pressure chamber environment alkaline, causing the neutralization of the acid stabilizer and allowing the coupling between the dye coupler and the diazo cations to occur. This resulted in the final formation of the azo dyes. A toning period was set up to define the nuances of the contrast better. This happened through steam distillation in the ammoniac-filled autoclave, and by regulating the duration and pressure of the film's permanence in the autoclave. In general, diazo films have a limited tonal range.

[5] The process refers to the method used to print on 16 mm cellophane film at the laboratories of Kalle & Co. AG

[6] A type of organic compound resulting from a reaction of primary aromatic amines with nitrous acid and mineral acid called a diazotization. Two properties of the diazonium cations are relevant to this reprographic method. Firstly, their chemical instability that leads them to react with couplers. Secondly, their light sensitivity, that leads to the decomposition of the diazonium salts and the liberation of nitrogen gas on exposure to ultraviolet light, leaving an inert product unable to couple.

[7] Organic compounds that are colorless, but that produce colors when combined with the diazo salts. The type of coupler determines the achieved color: Phenols give a brown, red-brown, and yellow-brown dye, Naphthols a blue dye and compounds with an active methylene a yellow dye.

4. Lacquer/coating: Since changes in humidity and temperature caused quite severe shrinkage of the material, the manufacturing included a coating phase. The film strips were coated either with a thin dip-lacquer or a highly concentrated stripping lacquer. According to documents from 1932 and a recipe from 1939, the most suitable coatings were nitrocellulose lacquers.

One physical characteristic of Ozaphan films that stands out is their yellow hue tendency, which is quite obvious when looking at light parts of the frames. Initially, the first thought regarding an explanation of this color tendency was the ageing of the material. However, the analysis of the monthly chemist's reports from Kalle & Co. AG pointed out that the yellow tone was a result of the phenol used during production. Kalle & Co. AG hoped to achieve a film as close as possible to regular black and white films, but after trying different diazo dyes, the phenol that gave the best results appeared to be phloroglucinol; even though, this compound left a yellowish image.

The dark parts of the frames, therefore, are also not black, but differently to the light parts of the images, determining the hue is not as straightforward. In fact, after asking a small group of people which color they would describe the dark parts as, the answer varied between grey, green, or even blue-purple.

With this study, we aim to document Ozaphan's color characteristics by presenting a spectrophotometric and colorimetric analysis of these materials and to assess if the characteristics of film colors can be preserved digitally.

Materials and Methods

The spectrophotometric analysis of the Ozaphan films was performed using an X-Rite Eye-One Pro spectrophotometer using the open-source software i1Toolz. The instrument was used for measuring both emissive and reflective light (380-730 nm, with 10 nm steps). The instrument's light source used for reflectance measures is a gas-filled tungsten lamp, while for transmittance measures, we used a backlit LED panel.

After acquiring the reflectance and transmittance data, the spectra have been converted in XYZ, and sRGB colorimetric coordinates.

For this preliminary study, seven 16 mm Ozaphan films were analyzed; for each one, spectrophotometric measurements were done both for a light part as well as for a dark part. The films varied in their dating between 1935 and the '50s, even though it wasn't possible to date them precisely. The films differed in their state of preservation, which in this case has not been specifically considered during testing but was kept in mind during the evaluation of the results.

The measured samples are the following:

ACHT (From the film *Acht Jungen und ein Ball*, dated after 1938, catalogue nr. 290).

HUE (From the film *Ein Hühnchen kommt zur Welt,* dated around 1935, catalogue nr. 14052/B).

1940 (From the newsreel *Monatsschau nr. 1940,* dated 1940).

GAL (From the film *Der Galante Schupo*, dated around 1935, catalogue nr. 11008/B).

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1935 (From the newsreel *Monatsschau nr. 4 1935,* dated 1935).

GROOM (From the film *Le Groom Maladroit*, dated around 1938).

FALL (From the film *Fallenstellers Reinfall*, dated around 1950, catalogue nr. 269).

Results

It should be noted that the sensitivity of the sensor of the i1Pro Spectrophotometer for the transmitted light was slightly limited, therefore the graphs start from 420 nm.

Comparing the light parts

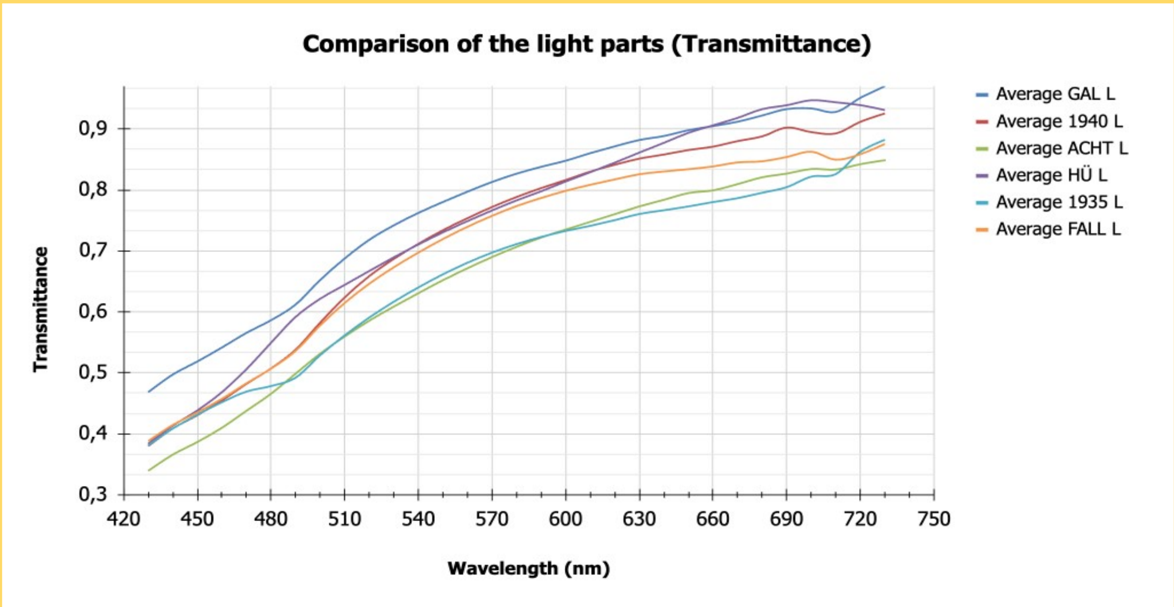


Table 1 - Transmittance of the light parts

From the comparison between the spectrums of the light parts from all samples, it is possible to immediately determine a generally rising trend, with only slight differences in the shape between the samples.

Four of the samples (GAL L, FALL L, 1940 L, ACHT L) show a change in the curve at 490-500 nm, where the spectrum stops having a relatively linear tendency and shows the start of a rise. This approximately corresponds with the peak of the color green at around 535 nm.

The spectrum of the sample “1935 L” is the one that showed up a bit differently. This difference is probably due to the part of the film that was selected for measurements for the light sample. The chosen frame was not completely clear and had some faint image parts, therefore more blue and green transmittance was captured.

Summing up, the transmittance of all samples is predominant between 500 nm and 740 nm, a range of light which is visible as going from green to red, therefore appearing as a yellowish light, with a slight red predominance. The difference in the light intensity could be attributed to different ageing stages or the presence of a patina of dirt on the films. For example, the film from the sample

"ACHT L", which showed up as less intense, did indeed have dirt residuals. Another hypothesis could be the different duration of the toning process, and therefore, different color intensity, as the process was probably never exactly the same.

For the film *Le Groom Maladroit* it has not been possible to measure a light sample, as no frame was considered suitable.

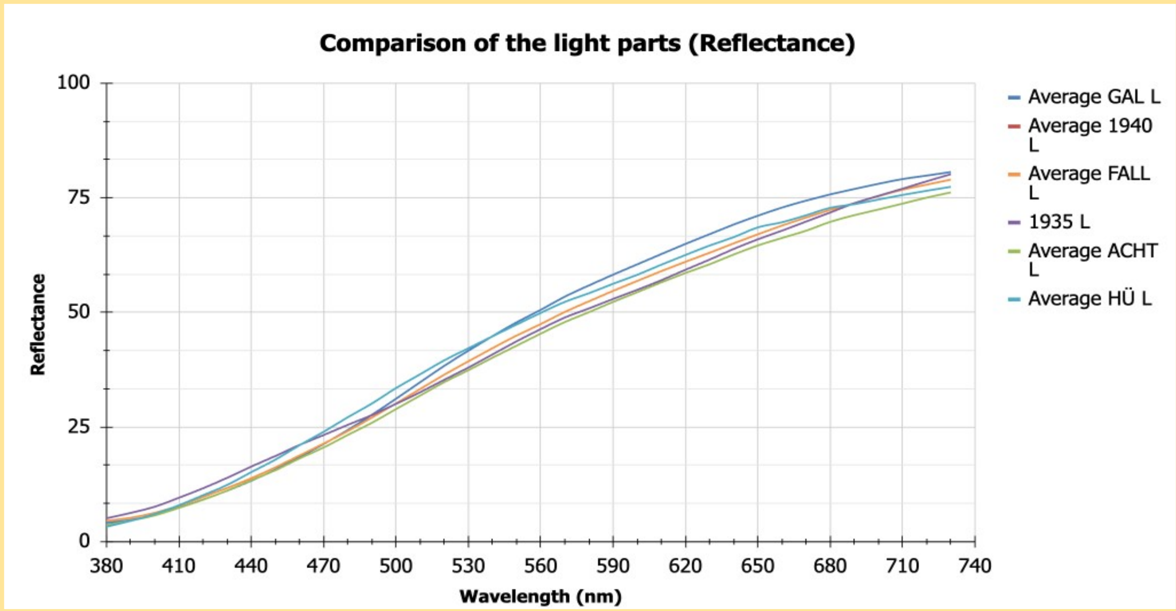


Table 2 - Reflectance of the light parts

The development of the transmittance curves and the reflectance curves proceed with a very similar trend. However, the reflectance curves are slightly more linear and don't show as much of a rise at 500 nm as do the transmittance curves.

Comparing the dark parts

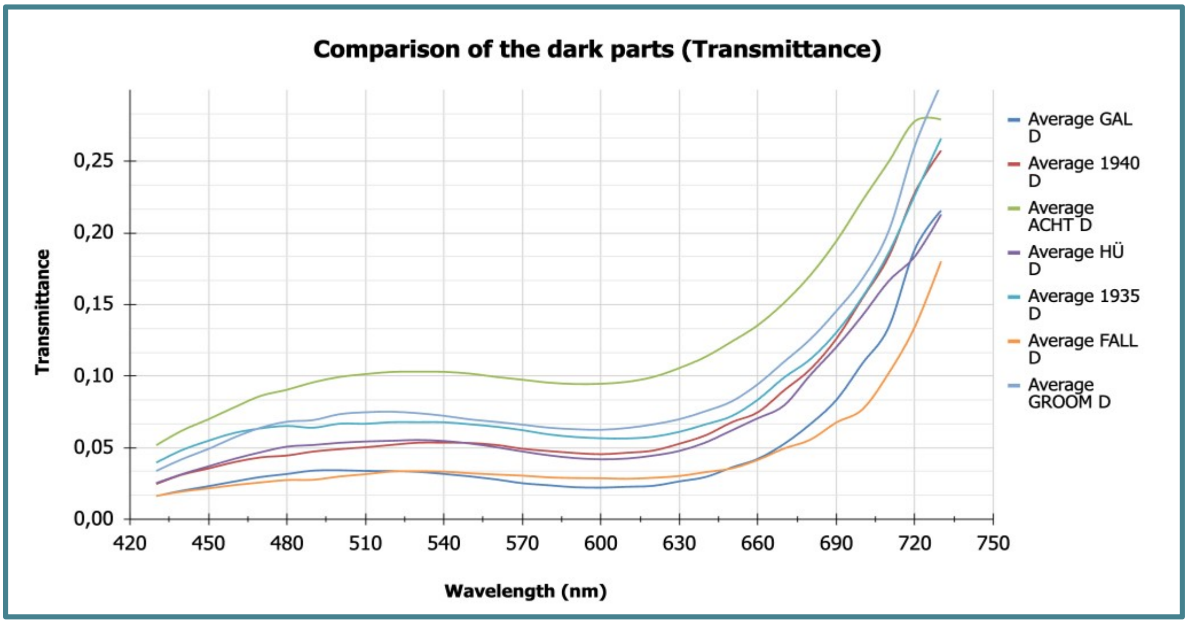


Table 3 - Transmittance of the dark parts

The general trend of most of the curves reaches a first high point at around 500-530 nm followed by a slight decrease, which shows that the dark parts have in fact a green hue tendency. From 630 nm the curves rise very steeply. The presence of orange and red could be either due to the fact of the previously discussed yellow undertone, or more likely it could be traced back to the presence of writing, and thus light parts, that were inevitable to be included in the measurements due to the size of the spectrophotometer's sensor. This contamination is particularly evident when looking at the measurements of the "ACHT D" sample that showed up lighter; the frame that had been selected included a relatively large writing.

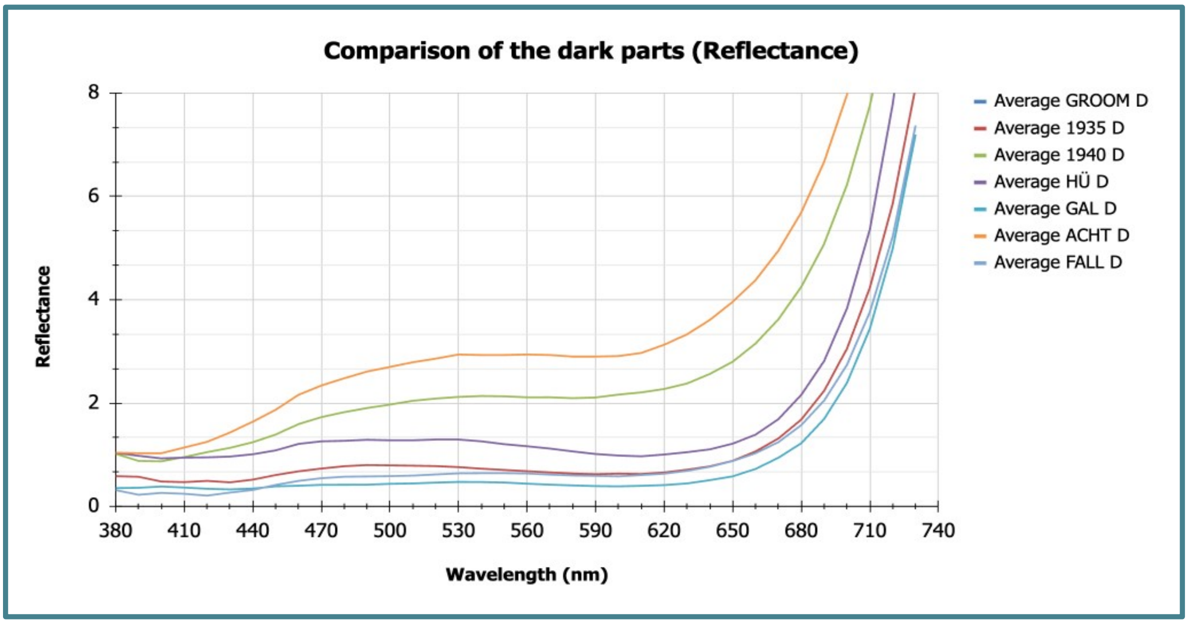


Table 4 - Reflectance of the dark parts

Just like for the light samples, when the development of the reflectance curves is compared to the ones of the transmittance curves, a clear correlation can be seen. The curve that stands out is the one from the "1940 D REF", for which the hypothesis of a human measuring error is plausible.

From Analog to Digital

During this study, four of the seven Ozaphan films that were used for the colorimetric measurements have been scanned. This has been an opportunity to experiment on how to try and preserve the colorimetric characteristic of the material as much as possible during the digitization and color correction. For this purpose, the computed RGB coordinates have been used to visualize the colors and can be used for comparison or as a reference. The goal was not to achieve the exact same RGB coordinates but to maintain the same balance between the three primary colors.

The Ozaphan films were scanned with the MWA Flashscan Nova scanner with a resolution of 2K and in 10 bits. It was evident already during the preview of the scan, that the colors represented in the digital image, didn't fully reflect the colors of the film material, they tended towards a warmer hue and with very little presence of green.

The first approach was to match the colorimetric values during scanning, but due to the limited control that the MWA software allows with the color wheels, this attempt was dropped.

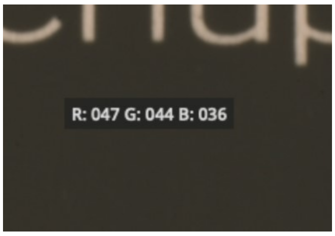
The second approach that was attempted aimed at applying RGB coordinates during the color correction process with the software DaVinci Resolve. A useful tool was the color picker which allowed the RGB coordinates of the digital image to be analyzed, and then regulate the RGB channels to try and match them with the values computed from the spectral data. To explain the procedure, we report an example of color correction for the film *Der Galante Schupo*.

After the film digitization, the first step consisted of adjusting the contrast to regain tone depth. The second step was aimed at matching the light parts. The RGB channels for *Highlights* and *Gain* were modified separately to reach a balance as close as possible to the reference RGB coordinates.

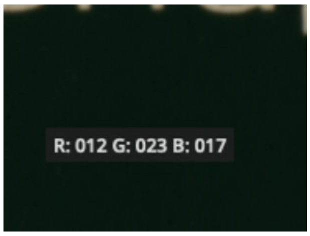
GAL C
240,40
227,00
192,13

Fig.1 - Result of the color correction of the light parts (right) after matching the scanned image (left) to the RGB coordinates (center).

The last step was to match the dark parts to the measured RGB coordinates by regulating the RGB



GAL D
39,22
49,86
44,07



channels individually, this time mainly for *Shadows*.

Fig.2 - Result of the color correction of the dark parts (right) after matching the scanned image (left) to the RGB coordinates (center).

The results and the method are experimental; however, the idea of using spectral measurements of the actual material, to try and maintain the characteristics even in the digital form, could be extremely useful to conduct more data-based and objective color corrections in film restoration.

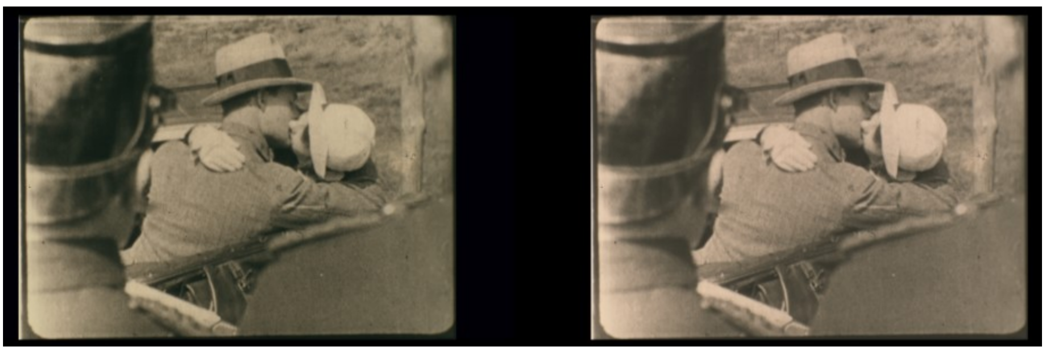


Fig 3. - After color correction (left) and before (right).

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Conclusions

Ozaphan films, produced from the late 1920s up to the 1950s in France and Germany, are among the less studied cinematographic materials. In this study we focused on the colors and tones analysis of these cellophane materials, first to document their spectrophotometric characteristics and second to assess how to preserve the films' color features digitally.

The spectrophotometric analysis, both in reflectance and transmittance, has been useful to assess the similarities, among materials of different ages and locations. Furthermore, the conversion into colorimetric coordinates allowed us to simulate Ozaphan-colors digitally and perform a data-based objective color correction.

In this context, it is important to remember the complexity of color perception, which cannot be simplified to a point-wise colorimetric conversion. Spectrophotometric and colorimetric measures should be used as a reference and be subject to the critical judgment of the restorer. As it was written in *A Material-Based Approach to the Digitization of Early Film Colours* we should not just use one «[…] single reference, but a multitude of references, or a field of references, that should be considered when we aim to emulate a film's appearance».

References

'Autoklav.' (c. 1939) Stadtarchiv Wiesbaden, WA 3, Nr.1150.

Baker, S. (2011) 'X-Rite I1 Pro', *TFTCentral.* Retrieved September 9, 2022, from http://tftcentral.co.uk/reviews/i1_pro.htm

'Die Fabrikation Des "Ozaphan"-Films.' (1935) Stadtarchiv Wiesbaden, WA 3, Nr.1150.

Dr. Spietschka and Dr. Krieger (1931) 'Monatsbericht', Stadtarchiv Wiesbaden, WA 3, Nr.1989.

Ducci, M. (2021) 'Diazotype – A Historical Copying Process', *World Journal of Chemical Education*, vol. 9, no. 4, pp. 136–143. Doi: 10.12691/wjce-9-4-6.

Flueckiger, B. *et al.* (2018) '12. A Material-Based Approach to the Digitization of Early Film Colours', *The Colour Fantastic: Chromatic Worlds of Silent Cinema.* Amsterdam: Amsterdam University Press, pp. 237-260. Doi: 10.5117/9789462983014/CH12.

Foster, R. and Goergen, J. (2020) *Heimkino auf Ozaphan: mediengeschichte eines vergessenen Filmmaterial*, Filmblatt-Schriften 11. Berlin: CineGraph Babelsberg

Hill, T. (1952) 'Nonsilver Photographic Processes', *Journal of the Society of Motion Picture and Television Engineers,* vol. 59, no. 1, pp. 58-66. Doi: 10.5594/J01185.

Lindbloom, B. (2017) 'Useful Color Equations', *Brucelindbloom.* Retrieved October 15, 2022, from http://www.brucelindbloom.com/.

Osterby, B. (1989) 'The Diazo Copying Process: An Example and Demonstration of Applied Organic Chemistry for the Undergraduate Student', *Journal of Chemical Education* vol. 66, no. 12, pp. 1026-1028. Doi: 10.1021/ed066p1026.