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Original article

Influence of disinfection methods on the stability of black and white silver gelatin prints

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ABSTRACT

Disinfection methods commonly used in paper conservation are employed to disinfect silver gelatin prints, but their influence on individual photographic layers is little understood. In this paper, we examine the effect of disinfection methods on the optical properties of the two layers of black and white silver gelatin prints: an image layer with a photosensitive substance dispersed in gelatin and a paper support layer with baryta coating. Three methods of disinfection were used: disinfection by γ-radiation, by ethylene oxide and by butanol vapors. Optical properties (total colour difference, UV-VIS reflectance) were measured after disinfection and again after subsequent artificial aging by moist heat and by light. The optical properties of the photographic image and paper support remained unchanged after disinfection in butanol vapors, which suggests that this is a promising disinfection method for silver gelatin photographic prints.

1. Research aims

This study was performed to examine the resistance of both silver gelatin prints as a whole and of the baryta paper support to several disinfection methods (γ-radiation, ethylene oxide and butanol vapors) and subsequent artificial ageing (by moist heat and by light) in terms of their optical properties.

2. Introduction

The various types of gelatin photographs form a very substantial part of the photographic collections of archives and libraries, as well as of private collections; silver gelatin prints are the most numerous in these collections [1,2]. These photographs consist of several layers of different materials: the paper support, the substrate layer made from the baryta coating and the light-sensitive layer, in which silver halide is dispersed in the emulsion medium (gelatin) [1,3,4]. But, during prolonged storage under unfavorable climactic conditions or in the case of disasters such as flood, mold and bacteria are able to easily grow on such organic substrates [5–7]. These microorganisms can cause serious damage such as making colour stains on the surface or even causing significant deterioration to the mechanical properties of the material, its embrittlement and, finally, complete disintegration. Furthermore, these organisms are harmful to human health. Therefore, it is necessary to eliminate this biological attack with an appropriate disinfection method [5,8,9].

In archives and libraries, it is useful to choose disinfection methods that can be collectively applied to a large number of infected items. Among these methods, we can use chemicals (e.g. ethylene oxide fumigation or less collectively applicable exposure to butanol vapors) or a physical interaction (e.g. with γ-radiation) [2,5,8,9]. When choosing a suitable disinfection method, care must be taken to thoroughly evaluate the properties of the treated material (including possible adverse effects) and its actual condition, as well as to assess its effectiveness and health risks for humans [5,7,9]. Because the risks associated with the various disinfection methods are well known in the case of paper support [2,9–14], the methods commonly used in paper conservation are also currently used for print disinfection.

In our previous work, we studied the effect of γ-radiation, ethylene oxide and butanol vapors on the stability of photographic gelatin in order to examine which method causes the smallest change, particularly in its molecular weight. The main result was that all three methods decrease the molecular weight in gelatin, but

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that these changes are least significant when butanol is employed [15].

Another important requirement in photograph conservation is to maintain optical stability; namely, to prevent undesirable fading or yellowing, that devalue the image [3,16]. In this field, only partial and inconsistent experimental results have been achieved to date; for example, it has been reported that ethylene oxide and γ-radiation of different doses (up to 90 kGy) do not influence the optical properties (optical density or total color difference) of silver gelatin prints on baryta paper [2,17]. But in these studies, the layered structure was not considered and, thus, changes in the optical properties of the paper support itself and of the photographic image were not distinguished. Moreover, only a very small amount of samples was used for these experiments. In the case of butanol, we are not aware of any information about its effect on the optical stability of photographs.

In this work, we focused on the effects of the above-mentioned disinfection methods (γ-radiation, ethylene oxide, butanol vapors) on the optical properties of silver gelatin prints. These optical properties were measured for the paper support layer with baryta coating itself and then for the black and white photographic image, whose individual tones were represented by grey scale fields. These findings, in combination with the results of a previous work [15], will serve as a basis for the selection of appropriate disinfection methods for silver gelatin prints, respecting the specificities of this complex material.

3. Methods and materials

3.1. Samples

3.1.1. Materials and chemicals

Samples of silver gelatin photographs with exposed grey scales were prepared using FOMABROM photographic paper with a sensitive layer (i.e. black and white photographic paper with fixed gradation in a gradation range of 60–120 ISO R, quality according to standard EN ISO 9001) produced by FOMA Bohemia, s.r.o., Hradec Králové. Further a standard TGE4 grey scale with 16 levels and size of 10 × 14 mm (produced by Daneš Picta, Prague) was used. On this 16-level scale, only levels 1–7 were used for this study. The samples of baryta paper consisted of photographic baryta paper without a sensitive layer (manufactured by FOMA Bohemia, s.r.o., Hradec Králové) with dimensions of 14.7 × 10.5 cm.

The developing process of the photographs was carried out using two commercial processing baths: FOMATOL LGN developer on the phenidone and hydroquinone basis (diluted in a ratio of 1 part of developer to 7 parts of distilled water) and fixer FOMAFIX P on the thiosulfate and sulfite basis (diluted in a ratio of 1 part of fixer to 5 parts of distilled water), both from the manufacturer FOMA Bohemia, s.r.o., Hradec Králové. Tap water was used as a stopping bath and for final washing of the photographs.

3.1.2. Sample preparation

Samples of photographic papers with a sensitive layer were exposed to light in contact with a grey scale for 62.5 ms in a photographic chamber. This was followed by developing in a developer for 90–120 s at a temperature of 20 °C. After interruption of the developing process in a stopping bath, the photographs were treated in a fixer for 6 min at a temperature of 20 °C. This was followed by rinsing in running water for 30 min at a temperature of 12–15 °C. The samples were dried by hanging freely without contact with a support at room temperature. The appearance of the resultant samples is recorded on Fig. 1a and b.

The baryta papers for measuring the total colour difference were not treated in any way (Fig. 1c). Small strips were prepared from

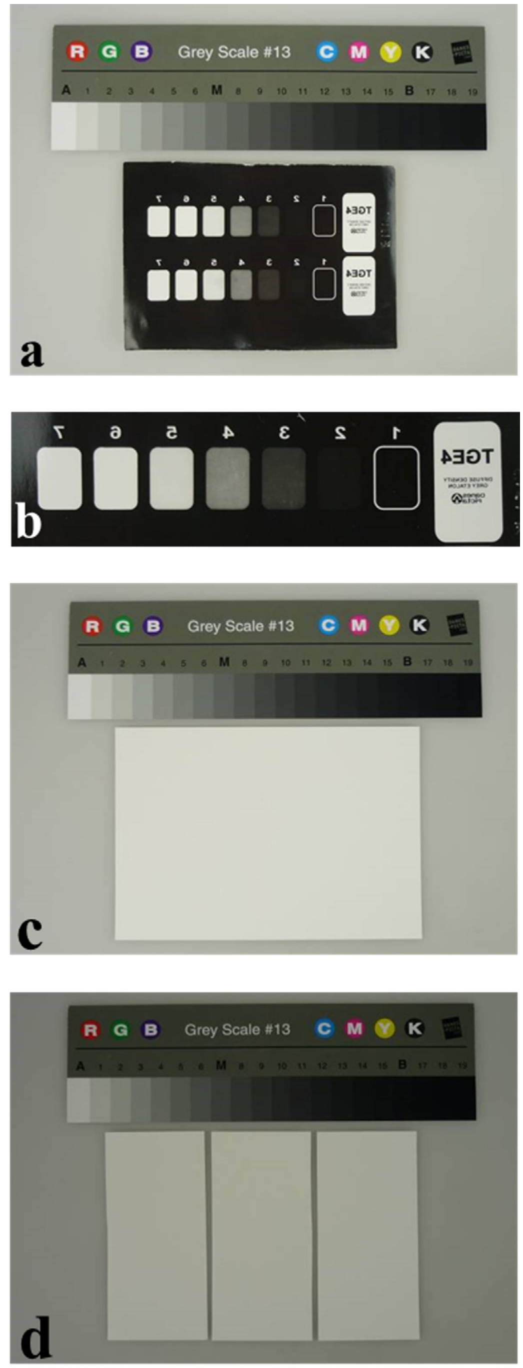

Fig. 1. Sample of black and white photograph (a), detail of exposed grey scale (b), sample of baryta paper (c), strips of baryta paper (d).

the supplied papers for UV-VIS reflectance spectroscopic measurements (Fig. 1d).

3.1.3. Test for residual thiosulfate

To verify the efficiency of rinsing, the content of residual thiosulfate from the fixing bath was determined according to the methylene blue test described in the ČSN ISO 417 [18]: thiosulfate was extracted from the sample, reduced to sulfide ion using borohydride and then converted to methylene blue by the reaction with N,N-dimethyl-*p*-phenylendiamin. Intensity of the blue colour in the solution was measured using the UV 550 UV-VIS spectrometer (Unicam, Great Britain) in the transmission regime at 665 nm.